THE

QUARTERLY JOURNAL

OF THE

GEOLOGICAL SOCIETY OF LONDON.

EDITED BY

THE ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

Quod si cui mortalium cordi et curæ sit non tantum inventis hærere, atque iis uti, sed ad ulteriora penetrare; atque non disputando adversarium, sed opere naturam vincere; denique non belle et probabiliter opinari, sed certo et ostensive scire; tales, tanquam veri scientiarum filii, nobis (si videbitur) se adjungant. —*Novum Organum, Præfatio.*

VOLUME THE SIXTEENTH.

1860.

PART THE FIRST.
PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

LONDON:
LONGMAN, GREEN, LONGMANS, AND ROBERTS.
PARIS:—FRIED. KLINCKSIECK, 11 RUE DE LILLE; BAUDRY, 9 RUE DU COQ, PRES LE LOUVRE; LEIPZIG, T. O. WEIGEL.
SOLD ALSO AT THE APARTMENTS OF THE SOCIETY.
MDCCCLX.

List

OF THE

OFFICERS

OF THE

GEOLOGICAL SOCIETY OF LONDON.

Elected February 17th, 1860.

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S. P. Woodward, Esq.

Assistant-Secretary, Librarian, and Curator.

T. Rupert Jones, Esq.

Clerk.

Mr. George E. Roberts.

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ERRATA AND CORRIGENDA.

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Page i, line 5, *for* two others *read* four others.
,, xxxiv, ,, 16, insert comma between *Orthis* and *Spirifer*.
,, xl, ,, 1, for *Turbellaria* read *Terebellaria*.
,, ,, ,, 4, for *Balanus tubidanis* read *Belemnites tubularis*.
,, xlviii, ,, 32, *for* luce *read* lucem.
,, li, line wanted between "Cænozoic" and "Mesozoic" in Table.
,, lv, ,, 8, *for* "tantum" &c. *read* "Tantum ævi" &c.
,, 67, line 13, *for* Clewyd *read* Clwyd.
,, 78, ,, 44, & p. 79, line 7, *for* Yordale *read* Yoredale.
,, 110, ,, 41, *for* those *read* that.
,, 118, ,, 25, *dele* Ordnance.
,, 158, ,, 3, *for* position *read* portion.
,, 170, last line, *for* ke *read* like.
,, 186, line 7, 8, & line 19, *for* Nutnoor *read* Hatnur.
,, ,, ,, 7, *for* Munoor *read* Manúr.
,, 188, ,, 20, *insert* Succinea *before* Nagpurensis.
,, ,, ,, 43, *for* Leithii *read* Leithi.
,, 191, ,, 7, *for* Amiens *read* Abbeville.
,, ,, ,, 48, *dele* resulting from mechanical forces.
,, 262, ,, 7, *dele* Abstract.
,, 289, ,, 27, *dele* comma after Latanof.
,, 290, ,, 1 *in note*, *for* on *read* in.
,, ,, ,, 2 *in note*, *for* lake *read* lakes.
,, 292, ,, 32, *after* Moll *insert* (1803).
,, 302, ,, 33, *for* trihedral (or *Cristellaria*, &c. *read* trihedral *Cristellaria* (*Saracenaria* of Defrance), and.
,, 321, ,, 1, *insert* Red *after* Old.
,, 424, ,, 9 & line 11, *for* Correbuichill *read* Correbuiehill.
,, 436, ,, 40, for *Aviculopecten*? read *Ammonite*?
,, 438, ,, 31, *after* Whale, *insert* Bell Sound, imbedded in moss, about 30 feet above the sea-level.
,, ,, ,, 33, *after* sea-level. *insert* From an entire skeleton.

EXPLANATION OF THE PLATES.

GEOLOGICAL SOCIETY OF LONDON.

ANNUAL GENERAL MEETING, FEB. 17, 1860.

REPORT OF THE COUNCIL.

In presenting their Annual Report to the Geological Society, the Council have to congratulate the Fellows on the flourishing state of the lists and finances. Although they must record with regret the loss by death during the past year of twenty-two Fellows,—making, with the resignation of two others and the removal of two defaulters, a total diminution of twenty-eight,—the addition of fifty-four Fellows newly elected, with twelve who were previously elected and who paid their fees in 1859, gives a total increase of no less than thirty-eight ordinary Fellows.

Two Foreign Members have been elected in lieu of two deceased, besides whom the Society has lost by death one personage of royal blood and two Honorary Members.

The total number of the Society at the close of 1858 was 872; at the close of 1859, 907.

The Income during 1859 has exceeded the Expenditure by £234 13*s.* 5*d.* In the disbursements is included the sum of £123 14*s.* 8*d.*, expended on the revision of the Greenough Map, on Books, and on the Museum, in accordance with the bequest of the late Mr. Greenough.

The amount of funded property remains the same as last reported, viz. £4578 19*s.* 2*d.*, including Mr. Greenough's legacy of £500. Of this latter sum, the total amount of £185 18*s.* 8*d.* has been disbursed as follows:—

	£	*s.*	*d.*
On the Greenough bequest of books	67	7	8
On the revision of the Greenough Map	68	11	0
On the Museum	50	0	0
	£185	18	8

and has been temporarily liquidated out of the ordinary expenditure of the last four years.

The Council have to announce the completion of vol. xv. of the Quarterly Journal, and the publication of the first part of vol. xvi. They moreover recently resolved that the Abstracts should no longer be published for distribution,—and that, taking into consideration the desirableness of bringing up the arrears of publication, a full Number of the Journal be published as a Supplement to the volume for 1859.

In pursuance of the announcement made in the Report of the Council of last year, a Special General Meeting of the Society was held on the 15th of June last, at which it was resolved that new Bye-Laws (Section VI. A., p. 9,) should be enacted, to the effect that Non-resident Fellows proposed and elected on and after the 2nd of Nov., 1859, should pay an Admission Fee of Six Guineas, and an Annual Contribution of £1 11*s.* 6*d.*

The Council have to report that two sheets of the new edition of the Greenough Map are now ready for publication, and that the remainder are in an advanced state.

A resolution has been passed, in order to increase the facilities for receiving the Journal, that the Non-resident Fellows who were elected before the 30th of Nov., 1859, be allowed to compound for future annual payments on account of that publication by a composition of £6.

In order to enable the Special Committee to carry out the rearrangement of the Museum, the sum of £50 from the Greenough bequest has been placed to the credit of that Committee. The Council have also voted a sum of £50 for the purchase of books reported on by a Committee as greatly required in the Library.

The Council have to announce the handsome bequest to the Society of £300 by the late Mr. John Brown, of Stanway, and the donation of £20 by Sir Thomas Phillipps, Bart., of Middle Hill.

Lastly, the Council have to state that they have awarded the Wollaston Medal to Mr. Searles V. Wood for his contributions to our knowledge of the Testacean Fauna of the later geological periods, and especially for his valuable work on the Crag Mollusca. The balance of the proceeds of the Wollaston Donation Fund are awarded to Messrs. T. Rupert Jones and W. K. Parker, to aid in their further researches on Recent and Fossil Foraminifera.

Report of the Library and Museum Committee.

Museum.

The Committee will first give an account of the Museum, as it cannot be doubted that the efficiency of the Geological Society as an instrument for promoting and extending sound geological knowledge must materially depend on the manner in which its Museum is arranged and rendered available to the student and inquirer, both of our own and of foreign countries. During the past year many valuable suites of specimens, both British and foreign, have been

presented to the Society by Sir R. I. Murchison, M. Boucher de Perthes, Mr. Horner, Mr. Heaphy, Dr. Atherstone, and others; but your Committee are obliged to state that, though some of these have been placed in drawers, the majority are not yet definitely arranged, for want of room,—thereby adding to the difficulty and confusion previously existing from the same cause, rather than tending to promote the interests of geological science.

Some little additional space for cabinets might be found in the Upper Museum; but your Special Committee, reappointed immediately after the last Anniversary Meeting, appear wisely to have considered that any remedy short of a careful re-examination of the entire Museum, and a re-arrangement of its contents, on some fixed principles, would only be a palliation, not a cure, of the evil so long complained of. It is, then, to this work of revision that your Special Committee appear to have given their uninterrupted attention during the past year; and it is evident that the same attention will be required to be given to it for a long time to come.

Some very important steps have been already successfully made towards the attainment of the preceding object,—namely, 1st. The collection of Recent Shells has been arranged and catalogued by Mr. Woodward, and, being placed in the Library, is most convenient for study or reference. 2nd. A Typical Collection of Rocks has been completed. The formation of this collection has been materially assisted by the discovery in the Museum of a systematic collection of 271 specimens of rocks, formed at Freyberg, fifty years ago, illustrating the nomenclature of the school of Werner. A catalogue of the whole with illustrative notes has also been prepared; and your Committee cannot but hope that this collection will materially tend to promote a greater amount of precision in the description of rock-masses, and thus bring into correlation, not merely the palæontological, but also the physical and lithological condition of different portions of the Earth. 3rd. The Collection of simple Minerals is now in order; and, the place of each mineral in the cabinet being noted in the Library-copy of Phillips' 'Mineralogy' (the collection having been arranged according to that system), reference is no longer attended with any difficulty, and the collection has become practically useful.

The result of the laborious examination of the Rock-specimens, effected by one of the members of the Special Committee, has demonstrated the obvious advantage of a similar revision of the fossil specimens. It is manifest that a satisfactory arrangement of these specimens cannot be accomplished so long as there is any uncertainty as to the amount of space disposable for their accommodation; and, therefore, it is recommended that an additional cabinet should be placed at the disposition of the Committee.

It appears that much voluntary aid has already been afforded towards the re-arrangement of the collections of fossils; the Rev. T. Wiltshire having undertaken, and made considerable progress in, the examination of the Chalk Fossils; Mr. Salter in that of the Palæozoic Fossils, up to the Devonian (of which the Upper Silurian

Series has been completed); and Mr. Etheridge has promised to undertake that of the Oolitic Series, which occupies 154 drawers. Without doubt, this and other voluntary aid which may be expected from many of our Members will do much towards the renovation of our Museum,—or rather, the establishment of a Museum such as it ought to be; but a perusal of a primary Catalogue of the Foreign Collection, drawn up by Mr. Horner, and the observation of the numerous undescribed specimens from all quarters of the world which it records, impress on your Committee the conviction that something more is required—nay, is absolutely indispensable.

The attention of Mr. Jones is every day more and more absorbed by the preparation for publication of the Journal,—a work on the character of which the reputation of the Society so much depends; and, although he has doubtless received much assistance from Mr. H. M. Jenkins, engaged in March 1859, and of whose assiduity and useful exertions he reports most favourably, it is evident that it was more in his character of Librarian than in that of Curator that he has principally benefited by Mr. Jenkins' assistance. Your Committee therefore fully concur with the Special Committee in recommending that a second temporary assistant should be appointed at a salary of 15*s*. per week. Such assistance, by relieving Mr. Jones and those Members who have so kindly assisted in the work of re-arranging the Museum from much manual or mere mechanical labour, will, it is hoped, accelerate the time when, the collection being weeded of all superfluous specimens, it will be possible to adopt and carry through a sound philosophical principle of arrangement. It is for your Special Committee to devise and mature the system of arrangement which to them appears the best fitted for securing this great object; and it is only for your present Committee to state that they fully concur in what that Committee has hitherto proposed; namely, that, at least in the first instance, the stratigraphical shall be subordinate to the geographical arrangement, as by this means the true succession of life in various regions will be more faithfully exhibited, and the correlation of one with another be facilitated.

Your Committee also consider that the Special Committee has acted most wisely in concentrating their attention principally on the Foreign Collection, as it is known to us all that for British geology the Museum in Jermyn Street affords every facility for reference; whereas the Museum of the Geological Society, when once placed in proper order, will be invaluable to those who desire to become acquainted with the details of foreign geology.

Your Committee trust that they have said enough to prove that active exertions are now being made, and in the right direction, to render the treasures in the Museum really available for the advancement of geological knowledge.

Library.

The necessary re-distribution of books on the shelves referred to in the last Report has been duly attended to, and completed; the new

press-marks and the entries in the Catalogue having been perfected. The condition of the Catalogue of Reference has been greatly improved.

The Alphabetical Catalogue of Books acquired since the year 1854, including those bequeathed by the late George Bellas Greenough, Esq., is in course of being printed.

The shelves last added in the Meeting-room are fully occupied, and chiefly by periodicals. There is a wall-space in the Library which may be made serviceable for additional book-shelves at the expense of £8. Your Committee recommend that this space be thus employed; it can be made available by the removal of some old maps into another position.

The usual binding of books and mounting of maps have been carefully attended to, and the arrangement of the map-cases is being improved.

The general state of the Library is satisfactory.

Among the numerous donations, we may point out that Sir Charles Lyell has liberally contributed to our library many books and pamphlets, among which are some rare and useful works. Through the kindness of Sir Roderick Murchison, Director-General of the Geological Survey, the Society has been favoured by Government with the newly coloured edition of the Maps of the Geological Survey of Great Britain. Prof. Agassiz has presented his unpublished drawing of Fossil Fishes.

The Council have had the satisfaction of being able to devote the sum of £50 to the purchase of British and foreign books on Geology and the associated sciences.

The acquisitions from Foreign Societies during the past year, in exchange for our publications, have been larger than previously.

Your Committee beg to repeat the suggestion that the List of British and Foreign Institutions receiving the Quarterly Journal gratis be revised.

One of the Fellows has been repeatedly and ineffectually applied to for three valuable books, which have been in his possession since April 1857. One volume each, of the 'Journal des Mines,' and of our 'Transactions,' are still absent since Oct. 1, 1850, although much exertion has been made towards their recovery. All trace of the Member offending is for the present lost. Some books long missing have lately been restored to the Library after considerable efforts.

Your Committee will conclude their Report on this especial head of the inquiry, by recommending that, in applying a certain portion of the funds of the Society to the augmentation of the Library, care should be taken first to supply any deficiencies which may exist in works of positive Geological and Palæontological interest.

LEONARD HORNER.

J. J. BIGSBY.

J. E. PORTLOCK.

Comparative Statement of the Number of the Society at the close of the years 1858 *and* 1859.

	Dec. 31, 1858.		Dec. 31, 1859.	
Compounders		121		120
Residents		192		200
Non-residents		493		524
		806		844
Honorary Members	12		10	
Foreign Members	50		50	
Personages of Royal Blood	4	—66	3	—63
		872		907

General Statement explanatory of the Alteration in the Number of Fellows, Honorary Members, &c. at the close of the years 1858 *and* 1859.

Number of Compounders, Residents, and Non-residents, December 31st, 1858			806
Add Fellows elected during former years, and paid in 1859	Residents .... 5; Non-residents . 7	—12	
Fellows elected and paid during 1859	Residents .... 21; Non-residents . 33	—54	
			66
			872
Deduct Compounders deceased		5	
Residents "		5	
Non-residents "		12	
Resigned		4	
Removed		2	
			28
Total number of Fellows, Dec. 31st, 1859, as above			844
Number of Honorary Members, Foreign Members, and Personages of Royal Blood, Dec. 31st, 1858			66
Add Foreign Members elected during 1859			2
			68
Deduct Foreign Members deceased		2	
Honorary Members "		2	
Personage of Royal Blood deceased		1	
			5
As above			63

Number of Fellows liable to Annual Contribution, as Residents, at the close of 1859, *with the alterations during the year.*

Number at the close of 1858		192
Add Elected in former years, and paid in 1859		5
Elected and paid in 1859		21
Non-residents who became Resident		2
		220
Deduct Deceased	5	
Resigned	4	
Removed	2	
Compounded	4	
Became Non-resident	5	
		20
As above		200

Deceased Fellows.

Compounders (5).

Thomas Brandram, Esq.
I. K. Brunel, Esq.
N. Malcolm, Esq.
Sir G. T. Staunton.
R. Stephenson, Esq.

Residents (5).

Dr. R. Bright.
W. J. Broderip, Esq.
Baron de Goldsmid.
Henry Hallam, Esq.
Dr. Horsfield.

Non-residents (12).

William Anstice, Esq.
John Brown, Esq.
Dr. John Booth.
Joseph Carne, Esq.
Lieut.-Gen. Earl Cathcart.
W. P. Craufurd, Esq.
Dr. J. G. Croker.
W. N. Forbes, Esq.
Rev. Dr. W. Jenkyn.
W. K. Loftus, Esq.
Sir James Ramsay.
Samuel Stutchbury, Esq.

Foreign Members (2).

Prof. Cleaveland.
Baron von Humboldt.

Honorary Members (2).

David Mushet, Esq.
Rev. William Turner.

Personage of Royal Blood.

Archduke John of Austria.

The following Persons were elected Fellows during the year 1859.

January 5th.—John Ford, Esq., Market Rasin, Lincolnshire; J. F. Josephson, Esq., Sydney; and C. F. Humbert, Esq., Watford.

—— 19th.—John Cavafy, Esq., Westbourne Terrace; William Whitaker, B.A. (Lond.), Geological Survey of Great Britain; and T. W. Atkinson, Esq., Old Brompton.

February 2nd.—Gennaro Placci, Esq., Florence; J. H. Sylvester, Esq., Malcoa, India; and J. F. Whiteaves, Esq., St. John Street, Oxford.

—— 23rd.—John Bainbridge, jun., Esq., Fishergate Villa, York; Richard Trench, Esq., Geological Survey of Great Britain; Dr. William Francis, Richmond; John Johnes, Esq., Dolau-Cothy, near Llandeilo; and Rev. T. W. Norwood, Cheltenham.

March 9th.—Thomas Codrington, Esq., Alresford, Hants; Walter Freeman, Esq., Brighton College; R. F. L. Jenner, Esq., Cardiff; Professor George Busk, Harley Street; John Hedley, Esq., Derby; Lonsdale Bradley, Esq., Richmond, Yorkshire; and John Miller, Esq., Thurso, N.B.

—— 23rd.—Capt. James H. Reid, Weymouth Street; Robert Mallet, Esq., Dublin; John McLandsborough, Esq., Bradford, Yorkshire; Charles Ratcliff, Esq., Downing College, Cambridge; Archibald Geikie, Esq., Geological Survey of Great Britain, Edinburgh; and John Hamilton Clement, Esq., Kensington.

April 6th.—James Phillips, Esq., Brixton Road; John Leckenby, Esq., Scarborough; John E. Lee, Esq., Caerleon, Monmouthshire; and Charles Gould, Esq., Geological Survey of Great Britain.

—— 20th.—Robert F. Williams, Esq., Coleshill Street, Eaton Square; and P. D. Tuckett, Esq., Holford Square.

May 4th.—Matthew Moggridge, Esq., Swansea; F. J. Mitchell, Esq., Newport, Monmouthshire; and Dr. Thomas Wright, Cheltenham.

—— 18th.—Richard Meeson, Esq., Grays, Essex; Graham Stuart, Esq., Sheffield; and Colonel S. C. Stepney, Llanelly, South Wales.

June 1st.—James Lamont, Esq., Knockdow, Argyllshire; and William Longman, Esq., Hyde Park Square.

—— 15th.—Major William E. Warrand, Southwell, Notts.

November 2nd.—William Fryer, Esq., St. John's Wood; Henry C. Salmon, Esq., Plymouth; and Rev. Samuel G. Phear, M.A., Emmanuel College, Cambridge.

—— 16th.—J. H. Tolmé, Esq., Queen Square, Bloomsbury; Thomas Harlin, Esq., M.A., Duke Street, Westminster; John Lancaster, Esq., Stoke-upon-Trent; Arnold Rogers, Esq., Hanover Square; and the Hon. Robert Marsham, Maidstone.

—— 30th.—Sir Walter C. James, Bart., Charles Street, Berkeley Square; George Dawes, Esq., Barnsley; Rev. J. E. Woods, Penola, South Australia; Bassett Smith, Esq., Elm Court, Temple; Capt. William Hichens, Bengal Engineers; Lionel Brough, Esq., Clifton; J. Studdy Leigh, Esq., St. Stephen's Terrace, Bayswater; and J. P. Hennessy, Esq., M.P.

December 14th.—J. H. Bass, Esq., Camden Road, Holloway.

The following Persons were elected Foreign Members.

March 9th.—Professor Achille Delesse, Rue de Madame, 35, à Paris.
November 2nd.—Professor Ferdinand Roemer, Breslau.

The following Donations to the Museum have been received since the last Anniversary.

British Specimens.

Two Specimens of Hyboclypus from the Cornbrash; presented by C. Hill, Esq.
Specimens of Echinidæ from the Upper Oolite of Gloucestershire; presented by J. Bravender, Esq., F.G.S.
Fossil Fish from the London Clay, and a Suite of Recent Shells; presented by W. J. Hamilton, Esq., For. Sec. G.S.
Suite of Devonian Fossils from Somerset; presented by J. D. Pring, Esq.
Specimens of Fossil Ferns from Burwash and Brightling; presented by the Rev. Joseph Gould.
Ammonites from near Ventnor; presented by Capt. Harvey, R.E.
Deposit in Boiler-pipes at Merthyr; presented by M. Moggridge, Esq., F.G.S.
Specimens from the Speeton Clay; presented by General Emmett, F.G.S.
Lepidotus teeth, &c. from the Wealden at Brook Point; presented by R. White, Esq., F.G.S.
Fossils from Brora, &c.; presented by Sir R. I. Murchison, F.G.S.
Tertiary Fossils from Peckham; presented by C. Rickham, Esq.

Foreign Specimens.

Specimen of Lithodomus in rock from Malta; presented by W. S. Clark, Esq., F.G.S.
Two Fossils from Hautville; presented by A. Majendie, Esq., F.G.S.
A suite of specimens of Fossil Shells and Bones from the Mayence Basin; presented by W. J. Hamilton, Esq., For. Sec. G.S.
Carboniferous and Devonian Fossils from Port Stephens, New South Wales; presented by the Australian Agricultural Society.
Specimens of Bryozoa and other Tertiary Fossils from South Australia; presented by the Rev. J. E. Woods.
Phosphorite from Spain; presented by Henry Thomas, Esq., F.G.S.
A Series of Celtic and Fossil Flint-tools from Abbeville; presented by M. Boucher de Perthes.
Series of Specimens from Egypt; presented by L. Horner, Esq., F.G.S.
Copper-ore from Ilicos, Philippine Islands; presented by Sir J. Bowring.
Specimens of Dendritic Granitello from Lima; presented by W. Nation, Esq.
Specimens of Coal, &c. from Auckland, New Zealand; presented by H. Weekes, Esq.

Specimens of Rocks and Fossils from New Zealand; presented by C. Heaphy, Esq.
Specimens of Fossil Plants, &c. from South Africa; presented by Dr. G. Atherstone.
Specimens of Apatite and Rutile from Snarum; presented by J. H. Clement, Esq., F.G.S.
Specimen of Red Lava from Madeira; presented by W. Phelps, Esq.
Fossils from Italy, India, &c.; presented by Sir R. I. Murchison, F.G.S.

Charts, Maps, &c.

54 Charts published by the Dépôt de la Marine; presented by the Director-General of the Dépôt de la Marine.
Geological Map of England and Wales; by Prof. A. C. Ramsay. Mounted in Case; presented by the Author.
Sheets, Nos. 10–16, 34, 42 N.W. S.W. S.E., 43 N.W. S.W. S.E., 45 S.W., 53 N.W. S.W. 54, 62 N.E, 62 S.E., 63 N.W. N.E. S.W., 71, 72 N.W., 73, 80 S.W. S.E. 82, 86, of the Geological Survey Map of Great Britain; Horizontal Sections, Nos. 22, 38–57; and Vertical Sections, Nos. 9, 19–25. Presented by the Director-General of the Geological Survey of Great Britain.
Map of Chicago Harbour and Bar, Illinois, by Lieut.-Col. J. D. Graham; presented by the Author.
Karte von dem Grossherzogthume Hessen—Section Schotten; presented by the Darmstadt Geographical Society.
Map of the First and Second Anthracite Coal-fields in Pennsylvania, by S. B. Fisher and P. W. Sheafer, 1849; presented by Sir C. Lyell, V.P.G.S.
Geologische Kaart van Nederland. Sheet No. 14 (Rijnland), by W. C. H. Staring; presented by the Author.
Overzigt der Geologie van Nederland, by W. C. H. Staring; presented by the Author.
United States Coast-Survey. Map of Point Reyes and Vicinity, California, 1855 (with Geological Indications).
———. Map of the Vicinity of the Golden Gate, San Francisco Bay, California, 1855 (with Geological Indications).
———. Map of the Vicinity of Monterey Bay, California, 1855 (with Geological Indications).
———. Map of the Country between San Diego and the Colorado River, California, 1855 (with Geological Indications).
Cartes Hydrographiques, Routières et Administratives des Provinces de Namur, Luxembourg, Brabant, Hainaut, et Liége, and Carte Topographique et Hygrométrique de Bruxelles; presented by M. Ph. Van der Maelen, F.G.S.

Coupe de Ste. Ménehouldt à l'Ardenne par Montmedy et Izel (Jamoigne), by M. Hébert; presented by the Author.
Section of the Coal-seams in the North Trough, neighbourhood of Neath, by D. Rees; presented by the Author.

Section of Strata in the Hampshire Basin, observed in making the Well for the Gosport Water-works, near Bury Cross, by James Pilbrow, Esq.; presented by the Author.
Section of a Boring at Purmerende, North Holland, December 1852; presented by G. R. Burnell, Esq.

Chart Illustrative of the Census of Victoria: Census-districts, and Distribution of the Population, March 29, 1859, by A. Robertson, W. Collis, and R. B. Smyth; presented by R. B. Smyth, Esq., F.G.S.
Diluvian Connemara Antiquities, by J. K. Boswell; presented by the Author.
Views of parts of the Seacoast of Tierra del Fuego. Taken on board H.M. Surveying Sloop 'Beagle,' 1829–39, 1831; presented by Sir C. Lyell, V.P.G.S.
Six Lithographic Portraits—Prof. Faraday, Prof. Owen, Dr. Hooker, Dr. Darwin, Prof. E. Forbes, and Prof. J. Phillips; presented by Prof. Tennant, F.G.S.
Lithographic Portrait of M. d'Orbigny; presented by M. Albert Gaudry.
4 Impressions of a Wood-cut of a small portion of Mr. Babbage's Difference-engine, No. 1; presented by C. Babbage, Esq.
8 Sheets of Lithographic Diagrams of Ventriculite-flints, Shells, and Foraminifera; presented by S. J. Mackie, Esq., F.G.S.

The following List contains the Names of the Persons and Public Bodies from whom Donations to the Library and Museum have been received since the last Anniversary.

Admiralty, Lords Commissioners of the.
Agassiz, Prof. L., For.M.G.S.
American Academy.
American Geological and Statistical Society.
American Philosophical Society.
Anderson, Rev. Dr. J., F.G.S.
Art-Union, London.
Asiatic Society of Bengal.
Athenæum Journal, Editor of the.
Atherstone, Dr. W. G.
Atkinson, T. W., Esq., F.G.S.
Atlantis, Editor of the.
Australian Agricultural Society.

Babbage, C., Esq.
Bache, Prof. A.
Barkway, E., Esq.
Barrande, M. J., For.M.G.S.
Basel Natural History Society.
Belgique, Société Paléontologique de la.
Berlin, German Geological Society at.
Berlin Royal Academy of Sciences.
Billings, E., Esq., F.G.S.
Binkhorst, Herr J. van den.
Blake, W. P., Esq.
Boston Society of Natural History.
Boucher de Perthes, M.
Bowditch, H. J., Esq.
Bowring, Sir J.
Bravard, M. A.
Bravender, J., Esq., F.G.S.
Breslau Academy of Sciences.
British Association for the Advancement of Science.
Burnell, G. R., Esq., F.G.S.
Buteux, M. C. J.

Campani, Prof. G.
Canadian Journal, Editor of the.
Chambers, R., Esq., F.G.S.
Chemical Society of London.
Cherbourg, Société Impériale des Sciences Naturelles de.
Clarke, W. L., Esq., F.G.S.
Clement, J. H., Esq., F.G.S.
Colonial Office.
Critic, Editor of the.
Cunnington, W. Esq., F.G.S.

Dana, Prof. J. D., For.M.G.S.
D'Archiac, M. le Vicomte, For. M.G.S.
Darmstadt Geographical Society.
Darwin, Dr. Chas., F.G.S.
Daubeny, Prof., M.D., F.G.S.
Daubrée, M.
Davidson, Thos., Esq., F.G.S.
Dawson, Dr. J. W., F.G.S.
Delesse, M. A.
Deslongchamps, Dr. J. A., For. M.G.S.
Dijon Academy.
Dobson, T., Esq.
Dublin Geological Society.
Dulau & Co., Messrs.

Edmonston & Co., Messrs.
Egerton, Sir P. G., Bart., M.P., F.G.S.
Eisenlohr, Dr.
Emmett, Gen., F.G.S.
Espy, J. P., Esq.

Fantuzzi, Sig. M. G.
Favre, Prof. A.
Forchammer, Dr. G., For.M.G.S.
France, Geological Society of.
Francis, Dr., F.G.S.

Gastaldi, Sig. B.
Gaudin, M. C. T.
Gaudry, M. Albert.
Geneva Natural History Society.
Geological Survey of the United Kingdom.
Geologists' Association.
Gibb, Dr. G. D., F.G.S.
Gilliss, Lieut. J. M.
Godwin-Austen, R., Esq., F.G.S.
Gould, Dr. A.
Gould, Rev. Joseph.
Graham, Col. J. D.

Halle, Society of Natural Sciences of.
Hamilton, W. J., Esq., For. Sec. G.S.
Harvey, Capt., R.E.
Haughton, Rev. Prof. S., F.G.S.
Hayden, Dr.
Heaphy, C. Esq.
Hébert, M. E.
Heidelberg, Natural History Society of.
Hennessy, Prof. H.
Harvey, Prof. J.
Hill, C., Esq.
Hogg, J.
Holmes, Prof. F. S.
Horner, L., Esq., F.G.S.
Horticultural Society.
Hunt, T. S., Esq.

India, Secretary of State for.
——, Geological Survey of
Institute of Actuaries.
Institute of Civil Engineers.

Jones, T. Rupert, Esq., F.G.S.
Jukes, J. B., Esq., F.G.S.

King, Prof.
Koninck, Prof. L. de, M.D., For. M.G.S.

Lachlan, Major R.
Laming, R., Esq.
Lartêt, M. E., For.M.G.S.
Lea, Dr. J.
Leeds Philosophical Society.
Liége, Société Royale des Sciences de.
Linnean Society.
Literary Gazette, Editor of the.
Liverpool Literary and Philosophical Society.
Low & Co., Messrs.

Lombardy Institute.
Lubbock, J., Esq., F.G.S.
Lyell, Sir Charles, V.P.G.S.

Mackie, S. J., Esq., F.G.S.
Martius, Dr.
Majendie, A., Esq., F.G.S.
Marcou, M. Jules.
Marmora, Gen.
Massalongo, Prof.
M^{c}Clelland, J., Esq.
Mechanics' Magazine, Editor of the.
Meek, F. B., Esq.
Mendicity Society.
Meteorological Society.
Meyer, Herr Herman von, For. M.G.S.
Michelin, M. H. G.
Microscopical Society.
Moggridge, M., Esq., F.G.S.
Montreal Natural History Society.
Morton, G. H., Esq., F.G.S.
Moscow Imperial Society of Naturalists.
Mouat, Dr.
Munich, Royal Academy of.

Nation, W., Esq.
Neuchatel Société des Sciences Naturelles.
Newbury, Dr. J.
Normandy, Linnean Society of.

Ohio, Board of Agriculture of.
Oldham, T., Esq., F.G.S.
Oppel, Dr. A.
O'Riley, E., Esq., F.G.S.
Ormerod, Dr., F.G.S.

Page, D., Esq., F.G.S.
Palæontographical Society.
Paris, Academy of Sciences of.
Paris, Ecole des Mines de.
Paris, M. le Directeur-Général du Dépôt de la Marine de.
Parish, Sir W., F.G.S.
Parker, W., Esq.
Perrey, A., Esq.
Phelps, W., Esq.
Philadelphia Academy of Natural Sciences.
Phillips, J. A., Esq.
Photographic Society.
Pictêt, Prof. F. J.
Pilbrow, J., Esq.
Ponzi, Prof. G.
Pring, J. D., Esq.

Ramsay, Prof., F.G.S.
Ray Society.
Rees, D., Esq.
Reeve, L., Esq., F.G.S.
Roberton, J., Esq.
Roemer, Prof. F., For.M.G.S.
Rose, G., Esq.
Royal Academy of Belgium.
Royal Asiatic Society.
Royal Astronomical Society.
Royal College of Physicians.
Royal Cornwall Polytechnic Society.
Royal Dublin Society.
Royal Geographical Society.
Royal Institution of Great Britain.
Royal Irish Academy.
Royal Society of London.

Sandberger, Dr. Fridolin.
Scharff, Dr.
Schlagintweit, MM.
Shumard, Dr. F.
Silliman, Prof. M.D., For.M.G.S.
Smithsonian Institute.
Society of Arts.
South Yorkshire Viewers' Association.
Statistical Society.
St. Louis Academy.
Steindachner, Herr F.
Stockholm Royal Academy of Sciences.
Studer, Prof. B., For.M.G.S.
Suess, Prof. E.
Swallow, G. C., Esq.

Tasmania, Royal Society of.
Tennant, Prof. J., F.G.S.
Thomas, Henry, Esq., F.G.S.
Tyndall, Prof.
Tyneside Naturalists' Field Club.

United States Patent Office.
United States War Department.
Upper Hesse, Natural History Society of.

Van der Maelen, M. Ph., F.G.S.
Vaudoise Society of Natural Sciences.
Victoria, Philosophical Institute of.
Vienna Berg-und-Hüttenman Association.
Vienna Geological Institute.
Villa, Sig. G. B.

Warren, Lieut.
Weekes, H., Esq.
White, R., Esq., F.G.S.
Williamson, J., Esq.
Wiltshire, Rev. T., F.G.S.
Wood, Ed., Esq., F.G.S.
Woods, Rev. J. E.
Wurtemburg Natural History Society.

Yates, Jas., Esq., F.G.S.

Zepharovich, Herr V. Ritter, von.
Zoological Society.

List of PAPERS *read since the last Anniversary Meeting, February* 18*th*, 1859.

1859.
Feb. 23rd.—On some Lias Deposits at Quarry Gill and other places near Carlisle, by E. W. Binney, Esq., F.G.S.
———— On the Fossils of the Lingula Flags, or Zone Primordiale; I. Paradoxides from Newfoundland, by J. W. Salter, Esq., F.G.S.
———— On the Dicynodon Murrayi, by Prof. Huxley, Sec.G.S.
———— On the Coal found by Dr. Livingstone at Tété, South Africa, by R. Thornton, Esq. (from the Foreign Office).
March 9th.—On the Veins of Tin-ore at Evigtok, Greenland, by J. W. Tayler, Esq., F.G.S.
———— On some Minerals from near Tabriz, Persia, by the Hon. C. A. Murray (from the Foreign Office).
———— On the Permian Chitonidæ of Durham, by J. W. Kirkby, Esq.; communicated by Thos. Davidson, Esq., F.G.S.
———— On Vegetable Structures in Coal, by Dr. J. W. Dawson, F.G.S.
March 23rd.—On some Reptilian Remains from South Africa and Australia, by Prof. Huxley, Sec.G.S.
———— On the Ramphorhynchus Bucklandi, by Prof. Huxley, Sec.G.S.
———— On the Dermal Armour of Crocodilus Hastingsiæ, by Prof. Huxley, Sec.G.S.
———— On a Fossil Cetacean and a Fossil Bird from New Zealand, by Prof. Huxley, Sec.G.S.
April 6th.—On the Inferior Oolite of Gloucestershire, compared with that of Yorkshire, by Dr. Thomas Wright; communicated by the President. With a Note on Dundry Hill, by R. Etheridge, Esq., F.G.S.
April 20th.—On some Reptilian Remains from South Africa, by Prof. Owen, F.G.S.
———— On the South-easterly Thinning-out of the Lower Secondary Rocks of England, by E. Hull, Esq., F.G.S.

May 4th.—On the Ossiferous Grotto di Maccagnone near Palermo, by Dr. H. Falconer, F.G.S.

———— On some Fossil Reptilian Eggs, from the great Oolite of the neighbourhood of Cirencester, by Prof. Jas. Buckman, F.G.S.

———— On the Jurassic Flora, by Baron A. de Zigno; communicated by C. Bunbury, Esq., F.G.S.

———— On some Sections near Oxford, by Prof. Phillips, Pres.G.S.

May 18th.—On the Nomenclature of the Old Red Fishes, by Sir P. G. Egerton, Bart., M.P., F.G.S.

———— On the Yellow Sandstone of Dura Den and some of the Old Red Fishes, by the Rev. J. Anderson, F.G.S.

June 1st.—On the sinking for Coal on the Shireoaks Colliery, by J. Lancaster, Esq., and C. C. Wright, Esq., F.G.S.

———— Notes of the Geology of Southern Australia, by A. Selwyn, Esq., in a Letter to Sir R. Murchison, F.G.S.

June 15th.—Notes on Spitzbergen, by James Lamont, Esq.; communicated by Sir C. Lyell, F.G.S.

———— On the Origin of Dolomites and Gypsums, by Sterry Hunt, Esq.; communicated by Prof. Ramsay, F.G.S.

———— On Tertiary Shells from Central India, by the Rev. S. Hislop; communicated by the President.

June 22nd.—Further observations on the occurrence of Objects of Human Art in the Bone-Breccia of the Caves near Palermo, by Dr. Falconer, V.P.G.S.

———— Report on the Progress of the Exploration of the Brixham Cave, by J. Prestwich, Esq., Treas.G.S.

———— On a Flint Implement recently obtained from the Gravel near Amiens, by J. W. Flower, Esq.; communicated by J. Prestwich, Esq., Treas.G.S.

Nov. 2nd.—On the Passage-beds between the Upper Silurian Rocks and the Old Red Sandstone at Ledbury, by the Rev. W. S. Symonds, F.G.S.

———— On some Mud-Volcanos near Carthagena, by F. Bernal, Esq.; communicated by Sir R. I. Murchison, F.G.S.

———— On the Coal found at Auckland, near New Zealand, by Henry Weekes, Esq.; communicated by the President.

———— On the Geology of Vancouver's Island, by H. Bauerman, Esq.; communicated by Sir R. I. Murchison, F.G.S.

Nov. 16th.—Supplemental Remarks on the Geology of the North-west Highlands of Scotland, by Sir R. I. Murchison, F.G.S.

Nov. 30th.—On some Bronze Relics found in a Gold-bearing Sand in Siberia, by T. W. Atkinson, Esq., F.G.S.

———— On the extinct Volcanos of Auckland, New Zealand, by C. Heaphy, Esq.; communicated by the President.

———— On some Tertiary Beds in South Australia, by the Rev. J. E. Woods; communicated by the President.

Dec. 14th.—On some Bones of Polyptychodon, from the Chalk of Dorking, by Prof. Owen, F.G.S.

———— On some new Reptilian Remains, with Shells of Pupa,

and an Iulus, from the Coal-Measures of Nova Scotia, by Dr. Dawson, F.G.S.

Dec. 14th.—On some Fossils from Bahia, by S. Allport, Esq.; communicated by Prof. Morris, F.G.S.

——— On some Cheirotherian Tracks in the Upper Keuper of Warwickshire, by the Rev. P. B. Brodie, F.G.S.

1860.

January 4th.—On the Lower Palæozoic Fauna, by Prof. Goeppert, For.M.G.S.

——— On the Freshwater Tertiaries of Southern Bessarabia and the Dobrutcha, by Capt. T. Spratt, F.G.S.

——— On the Recent and Fossil Foraminifera of the Mediterranean Area, by T. R. Jones, Esq., F.G.S., and W. K. Parker, Esq.

January 18th.—On some Sections South of Oxford, by Prof. J. Phillips, Pres.G.S.

——— On the Old Red Sandstone of the Grampians by Prof. Harkness, F.G.S.

——— On the Old Red Sandstone of the South of Scotland, by A. Geikie, Esq., F.G.S.

February 1st.—On some Cretaceous Rocks in Jamaica, by L. Barrett, Esq., F.G.S.

——— On some Fossils from the Grey Chalk near Guildford, by R. Godwin-Austen, Esq., F.G.S.

——— On the Coal in the Chalk of Kent, by R. Godwin-Austen, Esq., F.G.S.

——— On the probable Extent of Land during and after the Secondary Period, by S. V. Wood, Jun., Esq.; communicated by S. V. Wood, Esq., F.G.S.

February 15th.—On the probable Glacial Origin of some Norwegian Lakes, by T. Codrington, Esq., F.G.S.

——— On the Drift and Gravels of the North of Scotland, by T. F. Jamieson, Esq.; communicated by Sir R. I. Murchison, F.G.S.

After the Reports had been read it was resolved,—

That they be received and entered on the minutes of the Meeting; and that such parts of them as the Council shall think fit be printed and distributed among the Fellows.

It was afterwards resolved,—

1. That the thanks of the Society be given to Dr. J. Bigsby and Dr. Falconer, retiring from the office of Vice-President.

2. That the thanks of the Society be given to Thos. Davidson, Esq., Dr. Falconer, Prof. Ramsay, and the Rev. Dr. Whewell, retiring from the Council.

3. That the thanks of the Society be given to Prof. Phillips, retiring from the office of President.

After the Balloting-glasses had been duly closed, and the lists

examined by the Scrutineers, the following gentlemen were declared to have been duly elected the Officers and Council for the ensuing year:—

OFFICERS.

PRESIDENT.

Leonard Horner, Esq., F.R.S. L. & E.

VICE-PRESIDENTS.

Sir Charles Lyell, F.R.S. & L.S.
Sir R. I. Murchison, G.C.St.S., F.R.S. & L.S.
Major-General Portlock, LL.D., F.R.S.
G. P. Scrope, Esq., M.P., F.R.S.

SECRETARIES.

Prof. T. H. Huxley, F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.

FOREIGN SECRETARY.

William John Hamilton, Esq., F.R.S.

TREASURER.

Joseph Prestwich, Esq., F.R.S.

COUNCIL.

John J. Bigsby, M.D.
Sir P. G. Egerton, Bart., M.P., F.R.S.
R. A. Godwin-Austen, Esq., B.A., F.R.S.
William John Hamilton, Esq., F.R.S.
Joseph D. Hooker, M.D., F.R.S. & L.S.
William Hopkins, M.A., LL.D., F.R.S.
Leonard Horner, Esq., F.R.S. L. & E.
Prof. T. H. Huxley, F.R.S.
Sir Charles Lyell, F.R.S. & L.S.
Prof. W. H. Miller, M.A., F.R.S.
John C. Moore, Esq., M.A., F.R.S.
Prof. John Morris.
Sir R. I. Murchison, G.C.St.S., F.R.S. & L.S.
Robert W. Mylne, Esq.
Prof. John Phillips, M.A., F.R.S.
Major-General Portlock, LL.D., F.R.S.
Joseph Prestwich, Esq., F.R.S.
G. P. Scrope, Esq., M.P., F.R.S.
Warington W. Smyth, Esq., M.A., F.R.S.
Thomas Sopwith, Esq., M.A., F.R.S.
Alfred Tylor, Esq., F.L.S.
Searles V. Wood, Esq.
S. P. Woodward, Esq.

LIST OF

THE FIFTY FOREIGN MEMBERS

OF THE GEOLOGICAL SOCIETY OF LONDON, IN 1860.

Date of Election.	
1808.	Professor L. A. Necker, *Geneva.*
1817.	Professor K. C. von Leonhard, *Heidelberg.*
1817.	Professor Karl von Raumer, *Munich.*
1818.	Professor G. Ch. Gmelin, *Tübingen.*
1819.	Count A. Breuner, *Vienna.*
1819.	M. Charles Lardi, *Lausanne.*
1819.	Sign. Alberto Parolini, *Bassano.*
1821.	M. Louis Cordier, *Paris.*
1822.	Count Vitiano Borromeo, *Milan.*
1823.	Professor Nils de Nordenskiöld, *Abo.*
1825.	Dr. G. Forchhammer, *Copenhagen.*
1827.	Dr. H. von Dechen, Oberberghauptmann, *Bonn.*
1827.	Herr Karl von Oeynhausen, Oberberghauptmann, *Breslau.*
1828.	M. J. M. Bertrand de Doue, *Puy-en-Velay.*
1828.	M. Léonce Elie de Beaumont, Sec. Perpétuel de l'Instit. France, For. Mem. R. S., *Paris.*
1828.	Dr. B. Silliman, *New Haven, Connecticut.*
1829.	Dr. Ami Boué, *Vienna.*
1829.	Professor J. F. L. Hausmann, *Göttingen.*
1829.	J. J. d'Omalius d'Halloy, *Namur.*
1832.	Professor Eilert Mitscherlich, For. Mem. R. S., *Berlin.*
1839.	Dr. Ch. G. Ehrenberg, For. Mem. R. S., *Berlin.*
1840.	Professor Adolphe T. Brongniart, For. Mem. R. S., *Paris.*
1840.	Professor Gustav Rose, *Berlin.*
1841.	Dr. Louis Agassiz, For. Mem. R. S., *Cambridge, Massachusetts.*
1841.	M. G. P. Deshayes, *Paris.*
1844.	Professor William Burton Rogers, *Boston, U.S.*
1844.	M. Edouard de Verneuil, *Paris.*
1847.	Dr. M. C. H. Pander, *Riga.*
1847.	M. le Vicomte A. d'Archiac, *Paris.*
1848.	James Hall, Esq., *New York.*
1850.	Professor Bernard Studer, *Berne.*
1850.	Herr Hermann von Meyer, *Frankfort on Maine.*
1851.	Professor James D. Dana, *New Haven, Connecticut.*
1851.	Professor H. G. Bronn, *Heidelberg.*
1851.	Colonel G. von Helmersen, *St. Petersburg.*
1851.	Dr. W. K. Haidinger, For. Mem. R. S., *Vienna.*
1851.	Professor Angelo Sismonda, *Turin.*

Date of Election.

1853. Count Alexander von Keyserling, *St. Petersburg.*
1853. Professor Dr. L. G. de Koninck, *Liége.*
1854. M. Joachim Barrande, *Prague.*
1854. Professor Dr. Karl Friedrich Naumann, *Leipsic.*
1856. Professor Dr. Robert Bunsen, *Heidelberg.*
1857. Professor Dr. H. R. Goeppert, *Breslau.*
1857. M. E. Lartêt, *Paris.*
1857. Professor Dr. H. B. Geinitz, *Dresden.*
1857. Dr. Hermann Abich, *St. Petersburg.*
1858. Dr. J. A. E. Deslongchamps, *Caen.*
1858. Herr Arn. Escher von der Linth, *Zurich.*
1859. M. A. Delesse, *Paris.*
1859. Professor Dr. Ferdinand Roemer, *Breslau.*

AWARDS OF THE WOLLASTON-MEDAL

UNDER THE CONDITIONS OF THE "DONATION-FUND"

ESTABLISHED BY

WILLIAM HYDE WOLLASTON, M.D., F.R.S., F.G.S., &c.,

"To promote researches concerning the mineral structure of the earth, and to enable the Council of the Geological Society to reward those individuals of any country by whom such researches may hereafter be made,"—"such individual not being a Member of the Council."

Since the year 1846, *the Medal has been struck in Palladium, in commemoration of the Discoverer.*

1831. Mr. William Smith.
1835. Dr. G. A. Mantell.
1836. M. L. Agassiz.
1837. { Capt. P. F. Cautley. / Dr. H. Falconer. }
1838. Professor R. Owen.
1839. Professor C. G. Ehrenberg.
1840. Professor A. H. Dumont.
1841. M. Adolphe T. Brongniart.
1842. Baron L. von Buch.
1843. { M. E. de Beaumont. / M. P. A. Dufrénoy. }
1844. The Rev. W. D. Conybeare.
1845. Professor John Phillips.
1846. Mr. William Lonsdale.
1847. Dr. Ami Boué.
1848. The Rev. Dr. W. Buckland.
1849. Mr. Joseph Prestwich, jun.
1850. Mr. William Hopkins.
1851. The Rev. Prof. A. Sedgwick.
1852. Dr. W. H. Fitton.
1853. { M. le Vicomte A. d'Archiac. / M. E. de Verneuil. }
1854. Dr. Richard Griffith.
1855. Sir H. T. De la Beche.
1856. Sir W. E. Logan.
1857. M. Joachim Barrande.
1858. { Herr Hermann von Meyer. / Mr. James Hall. }
1859. Mr. Charles Darwin.
1860. Mr. Searles V. Wood.

INCOME.

	£	s.	d.	£	s.	d.
Balance at Banker's, January 1, 1859	298	7	8			
Balance in Clerk's hands	12	14	3			
				311	1	11
Compositions received				126	0	0
Arrears of Admission Fees	105	0	0			
Arrears of Annual Contributions	69	6	0			
				174	6	0
Admission Fees of 1859				466	4	0
Annual Contributions of 1859				608	9	6
Dividends on 3 per cent. Consols				134	10	2
Publications:						
Longman and Co., for Sale of Quarterly Journal in 1858	54	9	0			
Sale of Transactions	32	8	6			
Sale of Proceedings	1	2	0			
Sale of Journal, Vol. 1–6..................	10	17	6			
" Vol. 7–12	29	10	6			
" Vol. 13	18	13	8			
" Vol. 14	74	0	6			
" Vol. 15*..................	127	12	11			
" Geol. Map of England	3	15	0			
" Library Catalogues	2	15	6			
" Ormerod's Index	12	4	0			
				367	9	1
				£2188	0	8

We have compared the Books and Vouchers presented to us with these Statements, and find them correct.

Jan. 27, 1860. ALFRED TYLOR, JAMES TENNANT, } *Auditors.*

* Due from Messrs. Longman and Co., in addition to the above, on Journal, Vol. XV.	£59	1	5
Due from Fellows for Subscriptions to Journ.	57	7	8
Due from Authors for Corrections	25	11	0
	£142	0	1

Year ending December 31st, 1859.

EXPENDITURE.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	29	8	4			
Fire Insurance	3	0	0			
House Repairs	8	18	11			
Furniture	38	0	7			
Fuel	34	2	0			
Light	29	14	2			
Miscel. House expenses, including Postages	54	2	0			
Stationery	27	17	3			
Miscellaneous Printing	34	5	0			
Tea for Meetings	24	11	7			
				283	19	10
Salaries and Wages:						
Assistant-Secretary	200	0	0			
Clerk	120	0	0			
Assistant in Library and Museum	47	0	0			
Porter	90	0	0			
House Maid	33	4	0			
Occasional Attendants	12	15	0			
Collector	25	2	0			
				528	1	0
Library				94	3	3
Museum				63	1	1
Diagrams at Meetings				14	7	6
Miscellaneous Scientific Expenses				12	10	8
Publications:						
Geological Map of England	55	0	0			
Transactions	12	15	7			
Proceedings (Abstracts, &c.)	48	9	8			
Journal, Vols. I.–VI.	1	12	2			
,, Vols. VII.–XII.	3	1	10			
,, Vol. XIV.	5	8	3			
,, Vol. XV.	524	6	11			
				650	14	5
Balance at Banker's, Dec. 31, 1859	531	7	9			
Balance in Clerk's hands	9	15	2			
				541	2	11
				£2188	0	8

The above Expenditure includes £123 14*s.* 8*d.* disbursed on account of the Greenough Fund, and which has to be returned.

Trust Account.

Receipts.

	£	s.	d.
Balance at Banker's, 1st of January 1859, on the Wollaston Donation Fund	31	14	2
Dividends on the Donation Fund of £1084 1*s*. 1*d*. Red. 3 per Cents.	31	6	0
	£63	0	2

We have compared the books and vouchers presented to us with these Statements, and find them correct.

JAMES TENNANT, ALFRED TYLOR, *Auditors*.

Jan. 27, 1860.

Payments.

	£	s.	d.
Award to Mr. C. Peach	29	12	8
Cost of Striking, Engraving, &c. Palladium Medal awarded to Dr. Charles Darwin	2	1	6
Balance at Banker's (Wollaston Fund)	31	6	0
	£63	0	2

Valuation *of the Society's Property; 31st December*, 1859.

Property.

	£	s.	d.	£	s.	d.
Due from Messrs. Longman and Co., on Journal, Vol. XV.				59	1	5
Due for Subscriptions to Journal				57	7	8
Due for Authors' Corrections in Journal				25	11	0
Balance in Banker's hands				531	7	9
Balance in Clerk's hands				9	15	2
Funded Property, £4578 19*s*. 2*d*. Consols, at 95*				4350	0	0
Arrears of Admission Fees (considered good)	44	2	0			
Arrears of Annual Contributions (considered good)	69	6	0			
				113	8	0
				£5146	11	0

[*N.B. The value of the Mineral Collections, Library, Furniture, and stock of unsold Publications is not here included.*]

Debts.

	£	s.	d.
Balance in favour of the Society	5146	11	0
	£5146	11	0

Jan. 30, 1860. JOSEPH PRESTWICH, *Treas*.

* This sum includes Mr. Greenough's Bequest of £500, which was funded temporarily. Mr. John Brown's Bequest of £300 will probably be received early this year.

Estimates *for the Year* 1860.

INCOME EXPECTED.

	£	s.	d.	£	s.	d.
Due for Subscriptions on Quarterly Journal (considered good)	45	0	0			
Due for Authors' Corrections	25	11	0			
				70	11	0
Arrears (See Valuation-sheet)				113	8	0
Ordinary Income for 1860 estimated:						
Annual Contributions				640	0	0
Admission Fees (supposed 35)				220	0	0
Compositions (supposed 6)				130	0	0
Dividends on 3 per Cent. Consols				134	10	2
Sale of Transactions, Proceedings, Geological Map, Library Catalogues, Ormerod's Index				150	0	0
Sale of Quarterly Journal	250	0	0			
Due by Messrs. Longman and Co. in June, for sale of Journal in 1859	59	1	5			
				309	1	5
Due to Library, &c. on account of Mr. Greenough's Bequest				67	7	8
Due on account of Geological Map (Greenough)				68	11	0
Due on account of Special Museum Committee				50	0	0
				£1953	9	3

* The £100 for the Museum and £100 for the Geological Map are not to be considered under the head of Ordinary Expenditure, but as advances on account of Mr. Greenough's Bequest of £500, left at the disposal of the Council for special objects. The balance brought from 1859 is £541 2*s.* 11*d.*

JOSEPH PRESTWICH, Treas.

Jan. 30, 1860.

EXPENDITURE ESTIMATED.

	£	s.	d.	£	s.	d.
General Expenditure:						
Taxes	30	0	0			
Fire Insurance	3	0	0			
House Repairs	10	0	0			
Furniture	25	0	0			
Fuel	35	0	0			
Light	32	0	0			
Miscellaneous House Expenditure	50	0	0			
Stationery	28	0	0			
Miscellaneous Printing	35	0	0			
Tea for Meetings	24	0	0			
				272	0	0
Salaries and Wages:						
Assistant-Secretary	200	0	0			
Clerk	120	0	0			
Assistant in Library, &c.	52	0	0			
Porter	90	0	0			
House Maid	40	0	0			
Occasional Attendants	12	0	0			
Collector	25	0	0			
				539	0	0
Library, New Books, &c.	150	0	0			
Museum, Ordinary Expenditure ...£ 50; ,, Special Expenditure* ...£100	150	0	0			
Diagrams at Meetings	15	0	0			
Miscellaneous Scientific Expenses	12	0	0			
Publications: Quarterly Journal	700	0	0			
,, Transactions	10	0	0			
,, Geological Map*	100	0	0			
				1137	0	0
				£1948	0	0
Balance in favour of the Society				5	9	3
				£1953	9	3

PROCEEDINGS

AT THE

ANNUAL GENERAL MEETING,

17TH FEBRUARY, 1860.

AWARD OF THE WOLLASTON MEDAL AND DONATION FUND.

AFTER the Report of the Council had been read, the President, Professor JOHN PHILLIPS, M.A., LL.D., F.R.S., placed in the hands of SEARLES V. WOOD, Esq., the Wollaston Medal, saying:—

Mr. SEARLES WOOD,—Attached to the study of Natural History in many of its branches, you have judged wisely in devoting your earnest attention to one special field of research and one definite object of publication. By the Monograph of the Crag Mollusca, you have accomplished this object in regard to one of the most remarkable of British Strata, and completed a research for which no one had equal opportunities. Seldom indeed concur, as in this instance, superior knowledge of the data, special powers of illustration, and a peculiar feeling of patriotic gratification in making known the fossils with which you had been familiar from childhood. While placing in your hands this well-earned tribute of respect, let me congratulate through you the Palæontographical Society, with whom your Crag Mollusca find an honourable place, in that they have been enabled to enrich their volumes with contributions of so finished a character by Naturalists so patient, persevering, and successful.

Mr. SEARLES WOOD said in reply:—

Sir,—I beg to return my grateful acknowledgements for the honour the Council of the Geological Society have conferred upon me, and I feel proud to find my labours have been so highly estimated by those who have worked in a similar field. My investigations in the Crag have been purely a labour of love. Residing for many years in the Crag country, I possessed great facilities for collecting its fossils. This Formation appeared to me to possess peculiar charms, uniting as it does the past with the present more perhaps than any other; and fate seems almost to have identified

me with it,—I was born in sight of one Crag pit, and shall probably be buried in sight of another.

The honour you have conferred upon me ought to be an incitement to further exertions; but the age at which I have arrived will not, I fear, permit me to promise much: the spirit is willing, but the flesh is weak.

I beg also to thank you, Sir, for the favourable opinion, as I was informed, you publicly expressed of my labours when you were in my native country about eight or nine years ago.

The President then addressing Mr. Jones and Mr. Parker, said:—

Zoologists and Palæontologists are equally indebted to your assiduous labours among the minute creatures which you have taught us to recognize through a large part of the Strata of the British Isles, and to compare with analogues now living, or representatives in distant regions. The long duration in time, the great variation of form, and the wide diffusion in space of these remarkable Microzoa render them objects of special interest to all who speculate on the succession of life and the mutability of species. Your researches, rich in definite facts, reduce the catalogues of species, but extend their recorded duration in time, and thus link several past geological periods with the life of the present ocean. To prove our sympathy in this your extremely intricate labour, the Geological Society has instructed me to place in your hands the proceeds of the Wollaston Donation Fund.

Mr. Rupert Jones thus replied:—

Sir,—Your kind and flattering observations on the Rhizopodal studies of my friend Mr. Parker and myself indicate rather the value of the subject of our researches than the results as yet attained by us. We hope that, favoured by time and circumstances, we may fulfil some at least of the anticipations which geologists and physiologists may expect from a patient, conscientious, and wide-extended examination of the recent and fossil Foraminifera.

We have come to the study by different paths,—my friend through physiological researches, while my motives have been chiefly palæontological. We believe that a painstaking criticism and comparison of the works of earlier naturalists, and a philosophical treatment of the mass of new materials now in our possession will tend to the best results.

If we have in our hand a clue to the elucidation of the history of these Microzoa, and of the part—the important part—that they have played in building up the stratified crust of the earth, we trust that careful perseverance will enable us to follow it up to some useful end, and to the working out of some good physical truths; and we feel especially gratified by the notice, Sir, you have taken of our researches, and by the kind encouragement which the Society has been pleased to bestow upon us.

THE ANNIVERSARY ADDRESS OF THE PRESIDENT.

Gentlemen,—Perhaps no single year since the origin of the Society has been so marked by the deaths of eminent members as that which is now terminated. To names conspicuous in literature, such as Hallam and Staunton, we must add the authors of our greatest engineering triumphs, Stephenson and Brunel,—naturalists of the highest rank, as Broderip and Horsfield,—geologists, mineralogists, and palæontologists, as Anstice, Brown, Carne, Cathcart, Loftus, and Stutchbury. These and others have passed from our list of Ordinary Members. From our Honorary list we lose the Rev. W. Turner and Mr. David Mushet, and from our Foreign list Professor Cleveland, Baron Humboldt, and the Archduke John of Austria. To several of these Members of our Society the Transactions and Proceedings are indebted for useful contributions;—to others we, in common with the whole literary world, are under lasting obligation.

Mr. William Anstice, resident in Shropshire, made good use of the facilities which he possessed of exploring the coal-fields of that country, and was rewarded by the discovery of fossil insects of the natural family of Curculionidæ, one of which worthily bears his name; and of Limulidæ*.

Richard Bright, M.D., found time, in the early part of that medical career which afterwards became famous, to notice the geological phenomena in the district with which his family has long been connected, and has communicated to our Society a paper on the strata in the vicinity of Bristol, embracing the series from the Lias to the Old Red Sandstone on the banks of the Avon†. Died December 16, 1858.

Mr. William John Broderip, slightly the senior of Dr. Buckland in Oxford, had the merit of assisting that eminent geologist in his earliest researches. Though Zoology, and especially the Molluscous animals, absorbed his attention in later years, in connexion with the Zoological Society, and the 'Penny Cyclopædia,' which was largely enriched by contributions from his ready and accurate pen, he found time to notice some fossil Crustaceans and Radiata discovered at Lyme Regis‡, and to assist theoretical geology by a valuable Table of the situation and depths at which recent genera of marine and estuary shells have been observed§. Died February 27, 1859.

Mr. John Brown paid close attention to the Pleistocene deposits in the vicinity of his residence at Stanway, and collected a remark-

* Prestwich in Geol Trans. v. 413. Buckland, Bridgewater Treatise, i. p. 396. and ii. pl. 46. figs. 1, 2, 3.

† Geol. Trans. iv. p. 193. ‡ Trans. Geol. Soc. ser. 2. v. p. 171.

§ De la Beche's Theoretical Researches.

able series of specimens of extinct Mammalia from that locality and other parts of Essex, especially from Clacton. He liberally supplied the Oxford and other Museums with Crag fossils, drawn from his own collections, and maintained to the last a strong and intelligent interest in our pursuits. As a final proof of his good will, he has left us a legacy of £300, to be employed without restraint in the advancement of his favourite science. Died 28th of November, 1859, in his eightieth year.

Mr. Joseph Carne was a much-honoured member of the Geological Society of Cornwall, to whose Transactions he communicated several memoirs on the tin- and silver-veins, granite rocks, and elvan-courses of the rich mineral district adjoining Penzance, the place of his residence. Died October 11, 1858, aged 77.

Earl Cathcart, better known to English and Scottish geologists under his earlier title of Lord Greenock, was remarkably well acquainted with the geology of several parts of Scotland, especially the Coal and Trap districts in the valley of the Clyde and Forth. He communicated memoirs on these subjects to the Royal Society of Edinburgh and the British Association. I was personally indebted to him and Mr. Milne, in 1834, for a valuable contribution to the first edition of my Map of the Geology of the British Isles. In after years Earl Cathcart collected largely from the Wealden deposits, and amassed a valuable collection of chalk-sponges from the shingle of Hastings. Died 1858, aged 76.

J. G. Croker, M.D., &c. Dr. Croker communicated a notice of the geology of the vicinity of Bovey Tracey, the place of his residence (Geol. Soc. 1856).

Sir I. L. Goldsmid, Bart., F.R.S., claims the grateful recollection of the Society on account of his liberal endowment of the Chair of Geology in University College, and other acts worthy of a generous mind. Died April 27, 1859, aged 81.

Thomas Horsfield, M.A., M.D., F.R.S. This eminent naturalist held for some years the office of Keeper of the Museum of the East India Company. His contributions to Entomology and other branches of Zoology are well known. He has left on record one proof of the interest he felt in studies familiar to us, in a mineralogical description of the Island of Bánká (Sill. Am. J. ser. 2. vii. 86). Died July 24, 1859, aged 86.

Mr. William Kennett Loftus imbibed under Professor Sedgwick a sound knowledge of geology, and always manifested a strong attachment to it, even when placed in circumstances which enabled him to render the most conspicuous services to geographical and historical researches. It was indeed this proved devotion to geology which led to his appointment on the Turco-Persian Commission; and his re-

searches in Mesopotamia produced also a series of brilliant antiquarian discoveries among the ruined cities of Assyria and Babylonia. On his return from the East, he was appointed to the Geological Survey of India; but his health, injured among the swamps of Assyria, failed entirely in India, and he died on his passage homewards, at the early age of 37. We are indebted to him for a notice of his geological observations on the structure of the plains of the Tigris and the mountain-ranges of Western Persia*.

Mr. David Mushet, besides communicating to the Society a section of the strata in the Forest of Dean, has claims on the respectful recollection of metallurgists on account of the attention he paid to the processes of the Iron-manufacture, first in the vicinity of Glasgow, and in later life in the Forest of Dean. In the latter district he was long resident, and no one was better acquainted with the peculiar oxides of iron there abundant, or more fertile of ingenious inventions in the process for smelting these or the very different ores in Lanarkshire.

Sir G. T. Staunton, F.R.S. While accompanying the celebrated embassy to China conducted by Lord Macartney, Sir G. Staunton found leisure to attend to a subject which has grown much in importance since the date of his volume (1797). He ascertained the quantity of sediment in the water of the Yellow River ($\frac{1}{200}$th), the quantity of water transported daily by this great stream, and the probable time in which, at the ratio assumed, the Yellow Sea (125,000 square-miles) would be filled up (24,000 years). Died August 10, 1859, aged 79.

Mr. Samuel Stutchbury, for some time Curator of the Bristol Institution, and remarkably skilled in the various branches of natural history, passed a portion of the later years of his life in the Geological Survey directed by the Government in Australia. We are indebted to him for a valuable account of the Low Coralline islands of the Pacific†, for notices of *Pachyodon*, *Avicula*, and *Plesiosaurus*, and, in conjunction with the late Dr. Riley, for a memoir on the Thecodont Saurians of the Magnesian Conglomerate near Bristol. Died February 12, 1859, aged 61.

The name of Professor Cleveland of New England, familiar to us by the application of it to a frequent kind of felspar, which he carefully studied, will also be gratefully remembered by geologists who are acquainted with his useful treatise on Mineralogy.

Alexander von Humboldt was born in 1769, the *annus magnus* of births, which also gave to Geology William Smith and George Cuvier. How different their destiny!—alike only in the eminent services each rendered to science. Smith, thoroughly English, never quitted for a day the island whose stratification was the study of his

* Geol. Journ. vii. 263, 1857. † Journal of the West of England.

life; Cuvier, contemplating in his rich museum the modern and ancient forms of life, established the science of Palæontology; while Humboldt, universal in genius and cosmopolitan in feeling, made it his chief delight

...... "ire per omnes
Terrasque tractusque maris cœlumque profundum."

The great Prussian was not specially nor even principally a geologist; yet, amidst the vast labours of his active life, he found many occasions of exercising the precepts of Werner, his early teacher at Freyberg, who also inspired his fellow-labourer Von Buch.

The special essays in which Humboldt records his own researches are too numerous, and embrace too wide a range of subjects to be discussed on this occasion. One of the earliest fruits of his Freyberg studies was a mineralogical notice of a basalt on the Rhine (1790); at another time he observed the diamonds and malachite of the Ural Mountains; he entered into the question of the ossiferous caverns (1817), studied the footprints of Hildberghausen, examined Infusoria, and reported to the Royal Academy of Sciences on a Table of Organic Remains (1825).

In the Essay on the Superposition of Rocks (1823), the principal phenomena which had come under Humboldt's personal observation during his travels in the two hemispheres are placed in comparison. We are indebted to him for a curious method of pasigraphical notation, adapted for recording and systematizing local observations on the position of rocks.

The study of volcanos and mountain-chains, in all their relations, geological, chemical, and meteorological—the contemplation of the living wonders of nature in relation to the distribution of land and sea and the ranges of climate,—researches of this order, characteristic of the mind of Humboldt, are well typified by the beautiful work entitled 'Aspects of Nature,' including considerations on deserts, the physiognomy of plants, the cataracts of the Orinoco, and the structure and action of volcanos. In the great work which agreeably occupied the latter years of his life, and brought before him the whole system of nature, geology finds the early and honourable place which it ought to occupy in the scale of natural science. The views collected in Humboldt's 'Kosmos' on the physical constitution of the earth, on earthquakes and volcanic phenomena, and on the origin and metamorphism of rocks, are extremely instructive, and will be perused with pleasure and profit even by those who prefer a different explanation of some of the phenomena. Birth, September 14, 1769; death, May 6, 1859.

To the Archduke John of Austria geology is indebted not only for the countenance which a person in his high position could afford it, but for the special diligence and intelligent zeal with which he advanced the geological survey of the extensive and interesting countries under the sway of the Imperial House. Simple and unostentatious in his tastes, more at home among the Styrian mountains than in the palaces of Vienna, he was always occupied in

mining, metallurgy, and other works useful to his country, and always happy to welcome the English visitor who carried a hammer and sketch-book. Few members of any reigning family have deserved so well of their contemporaries and posterity.

Geology, as we are continually reminded by friendly commentators, has fairly taken its place among the Inductive Sciences; and by acting in the spirit which has won our emancipation from the tyranny of hypothesis, we have established firmly the authority of real laws and phenomena. From time to time, indeed, the historical aspect of geology reveals itself, in efforts more or less unsuccessful, to tear aside the veil which hides the origin of things, and to deduce not only the modern features of the land and sea from ancient physical revolutions, but the actual forms of life on the globe from earlier types modified by some assumed law of variation operating through unlimited time. Let us not, while wandering in this dark labyrinth of cosmogony, lose our hold of the slender thread which may bring us back to the light of true philosophy.

Looking, indeed, at the practical character of the papers presented to our meetings, there would seem to be no need of such a warning to the Geological Society. The Foraminifera have been largely illustrated by Jones and Parker; Fossil Botany has been brought before us in a general sense by Göppert and De Zigno, and with minute microscopical detail by Dawson; Permian Chitonidæ are noticed by Kirkby; the Fossils of the Lingula-flags by Salter; the Fishes of the Old Red Sandstone by Egerton, and Anderson, and Symonds; *Rhamphorhynchus Bucklandii*, Crocodilian Remains, Reptiles from Africa and Australia, a Cetacean, and a Bird by Huxley; Reptilian Remains from South Africa by Owen; a New Reptile from the Coal-measures by Dawson; *Cheirotherium* by Brodie. The Cretaceous period is illustrated in England by Godwin-Austen's notices of the carbonaceous mass enclosed in the chalk of Kent, and of the fossils of the chalk of Guildford; and in Jamaica by Barrett. It is taken as the subject of a general and interesting speculation by Mr. Searles Wood, jun. The works of art in the gravel of Amiens and the caves of Sicily have been explored by Falconer, Prestwich, Flower, Godwin-Austen, and Lyell. Facts in Australian Geology are communicated by Selwyn, Burr, and Wood. Captain Spratt sends his observations on Bessarabia; Lamont on Spitzbergen; Codrington on the Glaciers of Norway; Murray on Fossils from the East Indies; Allport from Bahia.

At home, the Topographical Geology of Scotland has still charms for Murchison, Harkness, Geikie, and Jamieson; Binnie reports Lias in the plain of Carlisle; Hull measures the thickness of the strata in the Midland Counties which perhaps cover coal at a moderate depth; Lancaster and Wright make known the discovery of this precious material under the Permian beds of Worksop; while Bauerman finds it in Vancouver's Island, Livingstone and Thornton on the Zambesi, and Weekes and Heaphy in New Zealand.

Finally, Palæontology is employed by Wright and Etheridge to

settle the dubious question of the true age of the Lower Oolitic deposits in the North of England.

What a contrast is offered by this mass of willing though laborious, and consentaneous though scattered efforts, all tending to enlarge knowledge and fortify the basis of theory, with the heap of crude conjectures which formerly took the place now firmly held by the true, however imperfect, natural history of the earth, which we have founded on sections of the strata and classifications of organic remains!

When, seventy years ago, the author of the Map of the Strata of England and Wales began to teach some practical knowledge of the earth's structure to miners and farmers, to Boards of Agriculture and Directors of Canals, the language he employed was worthy of the simplicity of the man, the subject, and the auditors. The strata were deposited in succession—the lowest first, the uppermost last. Each stratum was in succession the bed of the sea; it contained the remains of the animals then living in the water; these remains were similar in different parts of the same stratum, but unlike in different strata. Thus was formed the scale of geological time, marked by stratification and confirmed by the fossils, which we now employ.

§ *Palæontological Data.*

The communications made at our meetings so rarely touch on theoretical subjects, that, but for the discussions which ensue, it might seem as if we had ceased to doubt, or ceased to hope and aspire after higher generalizations. In tracing the history of the strata, whether in neighbouring or in distant localities, we employ, without fear, the evidence of organic remains to determine the place of the rocks which contain them in the general scale of strata. Even when comparisons are made between the groups of strata on opposite sides of the Atlantic—as between the Trenton Limestone of New York and that of Llandeilo in South Wales*, or between the Silurians of Europe and their Arctic representatives in Prince Patrick's Land†,—the affinity of the fossils is accepted as evidence of the approximate contemporaneity of the rocks.

But beyond the ranks of our Society, among those who do not share our labours, are some who do not accept our conclusions. They doubt the logical applicability of our methods of reasoning to areas so wide, to conditions so dissimilar, and to times so remote. They doubt if the facts of succession of organic remains in the earth are sufficient, or sufficiently investigated, to justify the inferences common in our books regarding the succession of ancient life, in periods of long duration, under quite different aspects of nature.

Disbelief of this kind has in former times easily passed into hostility—

> Quodcunque ostendis mihi sic, incredulus odi;

but in these days it may often be removed by a better knowledge of

* See Rogers's Geol. Map of N. America; and Hall's Geology of New York.
† Haughton, Notice of Fossils found by M'Clintock.

the problems we examine and the conclusions we adopt. That better knowledge may lead wise and benevolent friends of science to favour our branch of useful knowledge by scholarships and fellowships, to be won by conspicuous merit at our universities, and employed for the benefit of our country in the field, in the senate, and the pulpit. If our data be not sufficient, if our reasoning be not right, the more thankful should we be to the friendly sceptic who puts us to the proof.

An objection to the cogency of our conclusions in regard to the history of the changes which the surface of the earth has undergone is founded on the incompleteness of the record which we find in the organic remains. It is *incomplete*, in some departments more than in others; but we must not admit it to be *insufficient* to sustain just conclusions; for these cannot extend beyond the data.

The main subject of the record by fossils is the history of the sea and its bed; and for this the data appear sufficient. They are incomplete in regard to fresh water, the land, and the air, and must ever remain so. It is only by the intercalation of reliquiæ derived from these, in the series of marine deposits, that we can assign to them their right date; and the occurrence of land and freshwater remains among marine deposits is, and must always have been, comparatively rare, and, with reference to the history of the ocean, almost accidental.

Still we must not undervalue the evidence thus afforded. The coal-deposits give us considerable information of the plants of one period, naturally growing and gathered together on the edge of the sea; from the trias, the oolitic coal-fields, the wealden and cretaceous deposits, we obtain a large and varied flora of the Mesozoic period; and many of the tertiary strata yield quite different groups of the later vegetations. Among the coal-deposits lie skeletons of several reptiles *, a few land and freshwater shells and articulata †; among the oolitic shore- and river-sediments lie mammalia, with many reptiles which lived on the land, or in fresh waters, or traversed the air; and in the tertiary group of strata the remains of all the vertebrated classes, including lacustrine and terrestrial races, occur in abundance. If we cannot thus reconstruct the whole animal and vegetable kingdom, we have numerous and instructive examples of both at certain important epochs in the three great geological periods.

To judge of the completeness with which individual groups are preserved to represent the whole series of that particular life, we may select some very distinct marine genera rich in species. Such occur among the Brachiopoda, Conchifera, and Cephalopoda. For example, *Terebratula*, possibly absent from all the Silurians, shows itself frequently in the Devonian, Carboniferous, and Permian strata; abundantly in the Lias, Oolites, and Cretaceous rocks; but sparingly in the Tertiary beds and in modern oceans. In this extensive series, the shells of the genus retain always the characteristic tubules, the

* *Archegosaurus* in Europe, *Dendrerpeton* and *Hylonomus* in Nova Scotia.

† Some recently found in the coal-deposits of Nova Scotia by Dr. Dawson, besides the insects of the English and European coal-beds.

hinge-apparatus is similar, the internal supporting shelly loops are similar, and the beak is similarly perforated. So *Rhynchonella* is common in the Silurian, Devonian, Carboniferous, and Permian rocks; abounds in the Liassic, Oolitic, and Cretaceous; but is hardly known in the strata above, and is rare in the modern sea. A surprising resemblance runs through all the groups, though, as in the case of *Terebratula*, the *facies* differs in each of the great periods, and, indeed, in the several systems in those periods.

Whoever considers these facts with attention and with good collections before him, can come to no other conclusion than that here nearly the whole series of the forms of these genera is preserved to us. The same conclusion is to be drawn from a study of *Lingula*—a Cambrian and Silurian, but also a living genus, which has left monuments in every group of strata, very little differing from the recent examples.

When, then, we find the groups of the *Orthis Spirifer*, *Leptæna*, *Producta*, and *Pentamerus* so remarkably terminated at this or that level, we are not required to interpose at each of these levels an enormous interval of time unrepresented by forms of life, any more than such a supposition is countenanced by the first appearance of these genera. These beginnings and endings have relation to the peculiarities of each genus and each species, and to the influences on each. While *Orthoceras* died out, and *Belemnites* began and ended, *Nautilus* lived on, with characters but little altered, through the Palæozoic and all later times, and is still a living genus. So *Trigonia*, beginning in the muschelkalk, maintains its place on the Australian shore; and *Pholadomya*, whose geological range is nearly the same, has still a representative in the sea at Tortuga.

One very important truth flows naturally from the examination of such groups as *Rhynchonella*, *Lingula*, *Pholadomya*, and others which have a long series of representatives in time. While the natural group existed, its main structural characters persisted, and its essential habits of life remained similar in all the lapse of time; so that we may feel confidence in applying to a fossil group the arguments founded on real and structural analogy with existing races.

By considering these and many other cases, it appears, with reference to the use we make of organic fossils in judging of the constitution of ancient nature, that we are not without sufficient data to determine the probable character of the atmosphere, and the probable character of climate; that we can trace the action of light on the eyes of the primeval trilobite, in exciting the growth of coral, and in tinting some of the shells; that we can class the animal population of every age according to its food, and thus, by just reasoning, arrive at a conspectus of the state of the land and sea, which, though incomplete, need not be regarded as erroneous.

Finally, whatever degree of imperfection may still cling to our collections of data, it is daily growing less and less by the world-wide industry of our zealous workmen. Few of the several periods of geology have been left without some natural monuments of the

state of the land, sea, and air at the time. Far removed as they may be, we can place them on their right step in the scale of time, and apply to them the methods of interpretation which have hitherto been found successful, because they proceed on the sure basis of the observed laws of phenomena now prevailing in nature, and in this respect follow the teaching of Hutton and the example of Lyell.

§ *Provinces in Space.*

The conclusion adopted by Brown, Forbes, Godwin-Austen, and most naturalists in regard to the plants and animals now in existence, is that each species of this vast multitude came into being at a determinate place, and spread from thence by natural means over the neighbouring tracts, sometimes arriving at very great distances and appearing in unexpected situations*. Thus natural provinces are constituted, each including a considerable number of forms peculiar to itself, with others communicated from beyond its boundaries. These provinces are not necessarily the same for animals as for plants, nor for all the families either of plants or animals†. The unequal facility of distribution of different races comes in further to disguise the classification in provinces. Still, with Botanists and Zoologists almost universally, the principle of referring each species to a definite local centre, and of constituting provinces for many species having proximate centres, has been firmly supported as a true representation of nature.

Cases of very limited distribution occur, as in the Galapagos, visited by Mr. Darwin, where a unique group of life enjoys what seems to be a separate small province characterized by the herbivorous *Amblyrhynchus* and several peculiar species of birds, which, however, on the whole manifest a great analogy to other species on the American Continent, with which these isles may once have been connected. By admitting local displacements of land and sea, Forbes found in many cases an easy explanation of the occurrence of some species and the absence of others in the fauna and flora of islands, mountains, and branches of the sea.

Each of these species is conceived to be perpetuated in essential structure and habits of life, though subject to some variations, at birth and during life, by the influence of surrounding circumstances. Thus varieties arise, which are sometimes continued in races. Such variations in the species appear, by experience, in some cases to have natural limits, and are supposed to be limited in all cases; though as to the amount of variation, and the width between the limits, naturalists are not always agreed. Some, with Linnæus‡,

* See, on questions of this kind treated in this manner, E. Forbes in Memoirs of the Geol. Survey, vol. i.; and Forbes and Godwin-Austen, Natural History of the European Seas.

† See Woodward's Treatise on Mollusca for a Map of the Distribution of this class of animals.

‡ The opinion of this great and thoughtful naturalist, as given in the 'Amœnitates Academicæ,' and in a condensed form in the 'Systema Naturæ,' includes more than one of the views proposed in later times. The philosophical parts of the writings of the illustrious Swede ought to be more familiar to naturalists than they appear to be.

extend the limits to include a whole natural genus; others contract them to species, and these very narrowly defined.

§ *Provinces in Time.*

Geologists have generally accepted these views, as they have done in regard to fixed truths of chemistry and mechanics; and they have added, from the evidence which their peculiar studies yield, a definite origin of each natural group in time, the approximate duration of the life of many, and the epochs of termination of several. Thus every specific form is conceived to have sprung into being at a certain point on the globe, at a definite epoch of time; its existence is traced through provinces of space and through periods of time, so that it has a real physical history.

For those who adopt this view, the course of reasoning on the succession of life on the globe is clear and convincing. It is, however, not universally adopted; but the hypotheses which have been framed to replace it (which always involve the idea of indefinite change of form, structure, and habits) would not, if adopted, materially affect the conclusions of geology, or change the practice of naturalists. If it is by the course of progressive change from older types that new specific forms have arisen, there must have been for each of these a time and a place when it began to manifest the new specific distinction. Geology needs not to discuss these hypotheses, sanctioned though they be by eminent names, amongst whom our Darwin is preeminent for powers of generalization operating on a large basis of personal observation*. None of them appear to be wholly without a foundation of fact, though none of them can be held to penetrate more than a small way into the mystery of the origin of species. We may grant, with Lamarck, the inherent power of an organic body to undergo some change, or to effect some self-development, by reason of the intensive or abnormal exercise of its organs; we may allow to external conditions some influence in modifying the sensible characters of species, which is so boldly claimed by the author of the 'Vestiges of Creation;' and we may agree with Mr. Darwin in his more practical view of the derivation of some specific forms of one period from others of earlier date by descent with modification. We may accept all this, and yet consistently retain the conviction that the changes which are possible by such causes are circumscribed within the many essential types of structure which appear to be a part of the plan of creation†.

* The work of this author on Fossil Cirripedia is one of the most remarkable examples of his former careful discrimination of species (Palæont. Soc.); while his latest publication, 'On the Origin of Species,' is the most elaborate essay yet produced in favour of the descent of all known forms of life from a small number of originally created types.

† In the following words of Linnæus, the attentive reader will perceive proof that some of the questions, now agitated with so much interest, have not been neglected by this great "Minister and Interpreter of Nature":—

"Supponas D. O. O. in primordio e simplici progressum ad composita; e paucis ad plura! adeoque a primo Vegetabili principio, tot tantum creasse plantas diversas, quot *ordines Naturales*. Has ordinum plantas IPSUM dein ita inter se generando miscuisse, ut totidem exorirentur plantæ quot hodie distincta

Life is a measured gift—limited to certain kinds of matter in which only it can appear, and to the chemical and mechanical forces which accompany it, act in it, and are acted on by it—confined within certain temperatures—contrived for certain conditions of residence, in air, and in water—destined to a stationary home, or permitted to wander—to crawl, to run, to leap, to dig, to fly, to swim, to float, by appropriate adjustments which may be called in our language very scientific applications of the laws of nature—guided by organs of sense constructed to work in harmony with the rays of light and the undulations of the air—endowed with calculated instincts, consciousness, and volition. He who thinks himself equal to the problem of connecting in his mind all these structures and adjustments, which appear so special and so various and each so wonderfully adapted to a special purpose—to derive all these determinate results from one formula of indefinite variation from one original germ of life,

> "Child of the earth and sea and sun and air"—

may well claim to be the equivalent representative in our time of that old philosopher

> "Qui genus humanum ingenio superavit, et omnes
> Restinxit stellas, exortus ut ætherius sol."

Another view, even more desperate, which would ascribe an indefinite origin to every definite form by the mere union of elementary forces, may be answered by the words of the Epicurean Poet—

> "....nequeant ex omnibus omnia gigni."

Neither Zoology nor Botany nor Palæontology can countenance the supposition of many local origins for one specific form which can be increased and diffused by known processes, nor more than one epoch for its production and duration. In this, as in so many other instances,

> "....Vestigia nulla retrorsum;"

the group once ended, like the period to which it belonged, returns no more.

That the recorded duration and area of distribution of species will be augmented, that the number of so-called species will be reduced by critical inquiry, can hardly be doubted by any one who is aware of Mr. Davidson's valuable labours on the Brachiopoda*, or those of Messrs. Jones and Parker on the Foraminifera†. By such labours as these, the characters of the species which are retained will gain rather than lose in distinctness; and we may with more confidence employ the purified nomenclature in reasoning on the early aspects of nature. Nor will the recognizable varieties lose their value in reference to time or physical conditions.

existunt *Genera.* Natura dein Genericas has plantas, per generationes ambigenas (quæ structuram floris non mutant) inter se miscuisse et multiplicasse in *Species* existentes, quotquot possibiles, exclusis tamen e numero specierum, ab ejusmodi generatione productis, Plantis *Hybridis*, utpote sterilibus."—*Syst. Nat.* edit. xiii.

* Monographs of the Palæontographical Society.

† Referred to in the Award of the Wollaston Donation Fund, p. xxvi

§ *Zones of Life.*

To complete our knowledge of a geological province, we should remember that, as in dredging the sea-bed account is taken of the depth of water, the force of currents, and the quality of ground, so in geological investigations of precision we should expect similar attention to the separate collections from the coarse sands and pebbles of the shore, the drift sands, the muddy expansions, and the calcareous rocks. The general results to which we are accustomed, which sum the whole into one catalogue for a given period, furnish no doubt, the best means of contemplating the system of life of the period; but in local monographs, and in monographs of species o groups, the exact distinctive characters of the repository should, as far as possible, be recorded. In regard to depth of water, it is only by the record left in the structure of the stone, and succession of laminæ, that we can find an independent measure; and in this Mr. Sorby has greatly helped us. A measure of depth derived from the analogy of the fossil to the recent groups is seldom to be implicitly trusted. We may remark, further, that a series of fossils for any system, to be complete, should include three groups—from calcareous, arenaceous, and argillaceous repositories; for these three sets of deposits are really contained in each natural system of strata. One of the earliest and most profitable exercises of my life was the making a catalogue of the fossils in the collection of W. Smith, before the removal of it to the British Museum. When I had, following my great relative's guidance, enumerated the 720 species of fossils in his collection, he set me to compose those tabular synopses of the distribution of the more remarkable groups of fossils in the several zones of stratification of which the Table of Echinodermata in the 'Stratigraphical System of Organized Fossils' (1817) is an example. No sooner were these constructed for a few groups, than two ideas were strongly imprinted on my mind:—

1. That the groups of fossils had some real relation to the mineral and structural characters of deposits; so that, while smooth oysters, *Gryphææ*, &c., were frequent in clays, and Terebratulidæ rare in them, we were to look for Zoophyta and Echinodermata in the calcareous bands; Spongiadæ in some sands and some particular limestones; few fossils of any sort in peroxidated sediments, coarse conglomerates, or pure sands of any colour. It appears to me that this class of inquiry is still not enough followed out, either by explorers in local districts or by the palæontologist of the study. With so much the more pleasure, therefore, I welcome the extended example of such studies given by Dr. Bigsby in his comparison of the Silurian Fauna of North America and Europe.

2. That in each great natural zone of fossils there was to be traced a poor origin, a rich development, and a subsequent decrease,—thus apparently giving to each great natural period a zóne of maximum fertility in species, in which, more than at any other time, the various orders of life acquire their full expression. With this idea in his mind, a palæontologist finds the whole Carboniferous period one, though in it are several zones distinguishable by the prevalence

of a few types, and by the paucity or absence of others—the maximum of marine life being about the top of the Scar Limestone, or the base of the Yoredale Series.

So in the Silurian series of the Malvern tracts, the maximum zone of life is in the Wenlock group, while from below (in the black shales) the numbers of species rise from almost zero to 176, and then dwindle again to zero in the Downton Sandstones, at the base of the Old Red. So in the Lias, the lowest beds yield very few shells, and no Ammonites or Belemnites; but from this the numbers swell rapidly to a maximum, which for many groups is in the Oolitic series of Bath (but for Ammonites and Belemnites is in the Lias), and decays to a minimum in the comparatively poor Oolites of Portland, Swindon, and Aylesbury.

In the Cretaceous strata we may perceive very clearly the influence of physical conditions on the zones of greatest fertility; for while the Mollusca generally are more abundant in the Greensands and Gault, the Amorphozoa, Foraminifera, and Bryozoa seem more to affect the Chalk, and specially the Upper Chalk, from which most of the Ammonites have disappeared. Fishes are most plentiful in the Upper Chalk.

Nor can we fail, whilst studying the distribution of the Cretaceous fauna, to perceive a distinction of north and south districts, if not provinces, within the limits of Britain. The northern chalk of Yorkshire is comparatively poor in fossils, and, instead of the *Belemnitella mucronata*, so common in the south, gives us in abundance *Belemnitella quadrata*, which the chalk of the Baltic exchanges for *B. mammillata*. Observations of this kind, well carried out, appear to justify the belief that in different or only occasionally connected basins the succession of forms might be somewhat different; and that groups might be analytically resolved into several stages in one tract, united together in a second, or complicated with new auxiliaries in a third.

The two most contrasted provinces of the middle Palæozoic strata (the Devonian and Welsh tracts) offer, in regard to their forms of life, a very marked difference: little but Fishes in the latter; abundance of Mollusca, Trilobites, Zoophyta, and Bryozoa in the former. The *latter* is a tract of mostly peroxidated sediments; the *former* has a large proportion of protoxidated rocks, and in these principally are the treasures of fossil life. Sediments brought in different directions, with germs of local groups of contemporaneous life, are indicative of these facts, which, besides, suggest to us the necessity of reconsidering with care the relation of the truly limited Devonian to the greatly expanded Carboniferous and Silurian strata.

In the case just mentioned, then, there is often traceable a concurrence and coextension of certain given fossils with certain mineral deposits—the fossils coextensive with and limited to those particular deposits. So also the deposit of Aymestry Limestone is the favourite home of the conspicuous *Pentamerus Knightii*, which may be looked for in vain where the limestone dies out in contemporaneous muddy shales. When the Bradford Clay disappears, the peculiar local fauna

of Farley Castle and Bradford, with its *Turbellaria*, *Apiocrinus*, and *Terebratula coarctata*, vanishes. So when the upper part of the Lias dwindles in passing southward from Cleveland, we lose *Leda ovum*, *Ammon Lythensis*, and *Balanus tubidanis*; while, on the other hand, as we proceed northward, and lose the Lower Lias shales, the bone-bed vanishes. When the Lias Limestone grows obscure, *Ammonites Bucklandi* and *A. Conybearii* cease; and this is the more striking, because at intervals, some of the Middle and Upper Lias fossils, not so limited in time, as *A. bifrons* and *A. heterophyllus*, reach the coast of Dorsetshire, and reappear on the Continent.

This unequal diffusion of definite forms of life may often be ascribed to the progress of oceanic currents, which transported at once the germs of life and the sediments in which they were buried. If we trace by this means some of the ancient currents of the sea for any particular epoch, we shall find, with surprise, some neighbouring tracts to have been almost unconnected; while very distant regions manifest some effective communication. Thus, while the Trilobites of Bohemia differ almost in every species from those of Scandinavia*, while only a small proportion of the fossils of North Devon occur in South Devon, the American genus *Maclurea* unexpectedly appears in the oldest limestones of the extreme north-west of Scotland, and Ammonites like those of Kelloway Bridge in Wiltshire are collected in the centre of Russia and at the mouth of the Indus. So in existing nature, when we find *Spirula* in so many distant basins of the sea, between which now are no connecting channels, we must appeal to earlier distributions of land and sea for the means of intercourse which no longer exist. Thus Nature in some material aspects retains, in the arrangements of life as well as in the form of land and the peculiarities of physical geography, traces of the history of an earlier time.

Another point which appears to be of great importance in tracing the history of life, is the thorough examination of what are conceived to be "passage beds" from one system to another. For example, the Lingula-flags make a very remarkable zone in the series of Lower Palæozoic strata, separated by a considerable interval from the more fossiliferous strata of Snowdonia. The dying-out of one group of life, and the introduction of the other, in relation to the mineral nature and structure of the masses, are worthy of special attention in the vicinity of Tremadoc. In the group of the May Hill Sandstones we trace very satisfactorily some of the circumstances which characterize the introduction of the Upper Silurian fauna. The Rev. W. Symonds has lately added some details of the right sort in regard to the succession of beds, and their contents, at the junction of the Old Red Sandstone with the Silurians†; and Mr. Baily has added to our knowledge of those "Upper Old Red" laminations which contain *Cyclopteris Hibernica* and *Anodonta Jukesii*, and prenunciate as it were the great Carboniferous system. To continue this subject, I may recall to attention the very interesting junctions

* Barrande and Murchison.

† Read to the Geological Society, Nov. 2, 1859.

ES, DRAWN UP BY

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P

Descriptions and Names.	AMMONITES	discus.		sphæricus.						Calloviensis.		
		1	2	3	4	5	27	28	29	30	31	32
		Volutions concealed.				ii dividing from a tubercle.						
		Back smooth, entire.										
STRATA. London Clay		...	...	...	...	...	...	...	...	...	...	...
Chalk		...	...	...	...	...	...	...	...	...	...	...
Greensand		...	...	...	...	...	...	...	...	...	...	...
Brick-earth		...	...	...	...	...	...	...	...	...	...	...
Swindon and Portland		...	...	...	...	...	...	...	...	...	...	...
Oaktree Clay		...	...	...	...	...	...	...	...	...	...	...
Clunch and Shale		...	...	...	...	...	...	*	...	...	...	...
Kelloways		...	...	...	...	...	...	...	...	*	*	*
Cornbrash		*	...	...	...	...	...	...	...	...	...	...
Fuller's Earth		...	...	...	...	...	...	...	...	...	...	...
Under Oolite		...	*	...	...	...	*	...	*	...	...	...
Sand		...	...	...	...	...	...	...	...	...	...	...
Marlstone		...	...	...	*	*	...	...	...	...	...	...
Blue Marl		...	...	...	...	...	...	...	...	...	...	...
Lias		...	...	...	...	...	...	...	...	...	...	...
Mountain Limestone		...	...	*a	...	...	...	...	...	...	...	...

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NOTE. (1) The Table was drawn up previous to s of Ammonites—some pro deposit; it was from the Upper Lias of Whitby. *a* In the original, each speci posby S nites escri ed

of the English Coal-measures with the Magnesian Limestone series, which generally show remarkable unconformity, but in a tract of Yorkshire are nearly or perhaps quite conformable. Here the exact nature of the mineral changes, and the zones of *Axinus*, *Strophalosia*, *Nautili*, *Mytili*, and other shells, will become better known by the progress of the Geological Survey, which is now extended to that region.

I may also refer to the still unsettled questions regarding the triassic or liassic affinities of the bone-bed and the lowest Lias shales, sands, and calcareous layers,—on which a valuable communication has reached us from Dr. Wright. This active palæontologist is proceeding with his careful survey of the several divisions of the Lias in the south of England, and accumulating data for the further discussion of the boundary (if it be necessary to draw as a line what nature marks as a zone) between the Upper Lias and the Inferior Oolite.

§ *Distribution of Ammonites.*

Throughout the Lias and the whole Oolitic system, the evidence of Ammonites is acknowledged by all geologists to be of the highest value in determining the place of detached deposits on the general scale of ancient life and time. This arises in a great degree from the circumstances that the whole group of true Ammonites is limited in time between the Trias and the Tertiaries, and that the species are very numerous, very definitely marked, traceable from youth to age, and grouped naturally into distinct assemblages, whose place in the succession is constant. On these grounds Dr. Wright may well be justified in attaching to them the same importance which was assigned to them by W. Smith, whose unpublished Table of the Distribution of Ammonites, drawn up by my own hands in 1817, is now laid before the Meeting. It forms one of a series of such attempts, of which an example has been printed, viz. the Table of *Echini*, in the 'Stratigraphical System of Organized Fossils' (1817). Von Buch's valuable labours on the Ammonitidæ are well known.

There yet remain a few unsettled points of classification of the English and Scottish strata of the Oolitic series, for which a precise knowledge of the sequence of Ammonitic forms may furnish a clear explanation. Dr. Wright has lately placed before the Society a proposal to assign to the Inferior Oolite of Yorkshire a portion of the sandy, shaly, irony and calcareous beds which Prof. Morris and myself have referred to the oolite of Lincolnshire, which at present stands for the representative of the Great Oolite of Bath. The evidence of fossils appeared even in 1825–1828 in favour of referring these oolites of Cave and Gristhorpe to the Inferior Oolite; but it seemed indecisive to me, and has appeared so to almost every subsequent inquirer. In the section referred to, between unequivocal Lias and unequivocal Cornbrash there have been gathered very few Ammonites in addition to what were mentioned in my volume. In addition to *Ammonites Blagdeni*, which was found at Gristhorpe so long ago, the diligent naturalists of Scarborough have collected

[Quart. Journ. Geol. Soc. vol. xvi., to face page xli.

TABLE OF THE DISTRIBUTION OF AMMONITES, DRAWN UP BY [illegible]IPS, UNDER THE DIRECTION OF WILLIAM SMITH, IN 1817.

Descriptions and Names.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ammonites	discus.		sphæricus.					planicostatus.								
	Volutions concealed.				Radii straight.						Radii curved.		Radii tubercled.			Radii dividing, but not from a tubercle.
	Back smooth, entire.				Radii entire.											Radii crossing the back.
	Back without either keel or sulcus round it.															
Strata.																
London Clay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chalk	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Greensand	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Brick-earth	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Swindon and Portland	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Oaktree Clay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Clunch and Shale	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Kelloways	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cornbrash	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fuller's Earth	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Under Oolite	...	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sand	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Marlstone	...	...	...	*	*	...	...	...	...	...	...	*	...	...	...	...
Blue Marl	...	...	...	...	...	...	...	*	*	*	...	...	...	*	...	...
Lias	...	...	...	...	...	*	*	*	*	...	*	*	*	...	*	...
Mountain Limestone	...	...	*a	...	...	...	...	...	...	...	...	...	...	...	...	...

Descriptions and Names.	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Ammonites		triplicatus.		communis.					sublævis.					Calloviensis.		
									Radii dividing from a tubercle.							
Strata.																
London Clay	...	...	...	*b	...	...	...	...	...	...	...	...	...	...	...	...
Chalk	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Greensand	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Brick-earth	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Swindon and Portland	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Oaktree Clay	...	*	*	...	...	...	...	...	...	...	...	...	...	...	...	...
Clunch and Shale	...	...	...	*c	...	...	...	...	...	...	...	*	...	...	...	...
Kelloways	...	...	...	*d	...	...	...	...	*	...	...	...	...	*	*	*
Cornbrash	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fuller's Earth	...	...	...	...	...	...	...	...	...	*	...	...	...	...	...	...
Under Oolite	...	...	...	...	...	...	...	...	...	...	*	...	*	...	...	...
Sand	...	...	...	...	*	...	...	...	...	...	...	...	...	...	...	...
Marlstone	...	...	...	*	*	...	...	*	...	...	...	...	...	...	...	...
Blue Marl	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Lias	...	...	...	*	...	*	*	...	...	...	...	...	...	...	...	...
Mountain Limestone	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Descriptions and Names.	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52
Ammonites										concavus.					elegans.		
	Radii straight.					Radii curved.			Radii tubercled.	Radii dividing.							Tubercled.
	Radii entire.																
	A keel without a sulcus on the back.																
Strata.																	
London Clay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chalk	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Greensand	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Brick-earth	*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Swindon and Portland	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Oaktree Clay	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Clunch and Shale	...	...	...	...	...	...	...	...	*	...	...	...	...	*	...	...	...
Kelloways	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cornbrash	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fuller's Earth	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Under Oolite	...	...	...	...	...	...	...	*	...	...	...	...	...	...	...	...	...
Sand	...	...	...	...	...	*	...	...	...	...	...	...	...	...	*	...	...
Marlstone	...	...	...	...	...	*	*	...	...	*	*	*	*	...	...	...	...
Blue Marl	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...
Lias	...	*	*	*	*	...	...	...	...	...	...	...	...	...	...	...	...
Mountain Limestone	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Strata.	53	54	55	56	57	58	59	60	61	62	63	64	65	66
Ammonites						Walcotii.								
	Radii entire.						Radii divided.		Radii entire.			Radii divided.		
	A keel between two sulci on the back.								A sulcus round the back.					
London Clay.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Chalk.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Greensand.	...	...	...	...	...	...	...	...	*	...	...	...	...	...
Brick-earth.	...	...	...	...	...	...	...	...	...	...	...	*	...	...
Swindon and Portland.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Oaktree Clay.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Clunch and Shale.	...	...	...	...	...	*e	...	...	...	...	...	...	...	...
Kelloways.	...	...	...	...	...	...	...	...	...	...	...	...	...	*
Cornbrash.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Fuller's Earth.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Under Oolite.	...	...	...	...	...	...	...	*	...	...	...	...	*	...
Sand.	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Marlstone.	...	...	...	*	*	*	*	...	...	*	...	...	...	...
Blue Marl.	...	...	*	...	...	...	...	...	...	...	...	...	...	...
Lias.	*	*	...	...	...	...	...	...	...	...	*	...	...	...
Mountain Limestone.	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Note. (1) The Table was drawn up previous to the publication, in 1817, of the 'Stratigraphical System of Organized Fossils,' which contains a few more names of Ammonites—some pro[illegible] calix, which is now called *A. Blagdeni*. *a* is *Goniatites sphæricus*. *b* was marked as of doubtful occurrence; it was probably a drifted specimen. *c* was erroneously marked in this deposit; it was from the Upper Lias of Whitby. *d*, a related species. *e*, erroneously marked in this deposit; it was from the Upper Lias of Whitby. (2) In the original, each speci[illegible] those to which names could be affixed from Sowerby's 'Mineral Conchology,' then in progress.

*Ammonites Murchisonæ** from the Dogger, *A. Humphreysianus*† and *A. Parkinsoni* from the Gristhorpe beds. These three species occupy in Gloucestershire three zones in the Inferior Oolite, in the order here mentioned. In the same order they are reported to lie on the Yorkshire coast,—*Ammonites Parkinsoni* occupying the higher zone in each case, and *A. Murchisonæ* the lower. This remarkable analogy makes the palæontological evidence in favour of the slightly greater antiquity of these oolitic beds preponderate, and renders a re-examination of the oolite of North Lincolnshire and South Yorkshire a very desirable work. I do not intend to neglect it.

§ *Beds below the Chalk.*

Nor are we entirely free from perplexity in regard to some other deposits long known and much considered. The great Wealden series, so interesting for its remains of the land and fresh waters, held its place in the Oolitic group, according to all geological works, until within a few years. It has now been transferred by several writers to the Cretaceous group. This has been done, however, without the discovery in it of Cretaceous species, without any question of the analogy to the Oolites,—of the flora, which much resembles that of Stonesfield—or the fauna (such as it is), whether invertebrate, as *Paludina* and *Unio*, or vertebrate, as *Lepidosteus*, *Megalosaurus*, and *Cetiosaurus*. No doubt *Hylæosaurus* and *Iguanodon* occur also in the Lower Greensand; but that is hardly a sufficient argument.

According to the view which seems to me probable, these Wealden beds re-appear near Oxford, and occupy some considerable tracts to the north-east, probably covered by, rather than mixed with, Lower Greensand beds, though not so distinctly as in the typical Wealden. The Red Chalk of Yorkshire is perfectly conformed to, and even alternates with, White Chalk, and was classed by me with that deposit. It has been referred by some later writers to the parallel of the Gault or Lower Greensand; and Hunstanton Cliff is often quoted in support of this view. But, as I am reminded by Sir C. Lyell, who has lately inspected the Speeton Cliffs, the Red Chalk occurs in a well at Mildenhall, in the White Chalk. I believe we must leave it in the natural alliance formerly assigned to it, or admit two bands of Red Chalk of unequal antiquity‡. In the blue clays at Speeton there occur, as I formerly remarked, Kimmeridge Clay fossils at the bottom, and Gault fossils at the top. In some late visits, I have marked several successive zones of fossils in this clay; I shall probably before long publish in a revised form my ancient section of the Coast, so as to include much additional information as to Speeton, Gristhorpe§, and the northern cliffs.

* I have observed this species among the fossils of the oolitic Dogger beds (Inferior Oolite) of Thirsk, collected by the Rev. C. Johnstone.

† This I also found at Gristhorpe, 1855.

‡ General Emmett finds the Red Chalk of Yorkshire to contain a very large proportion of calcareous matter, and to be in some specimens full of Foraminifera. My specimens from Hunstanton are very full of *Rotaliæ*.

§ In the section of Gristhorpe Cliff printed in Geol. Journ. vol. xiv. p. 89,

§ *Palæontological Periods.*

When tracts of the old sea-bed so far apart as Wales from Lisbon, Bohemia, Sweden, or New York, the Arctic zone, the Himalaya range, or China are compared, and in all these countries the lowest strata are found to be filled with many forms of life remarkably similar*, not only in the mass of the rocks, but also often in the several groups of strata one above another, taken in the same order, geologists conclude that these strata, which, taken separately or taken in mass, have such remarkable agreement, were produced in the same period of the earth's history. The agreement of the fossils being for the most part due to the deposition of the strata in one oceanic basin, or to the free communication between one such basin and another, so that the species of marine animals might be diffused over parts of each, we have no reason to doubt that similar successions of deposits—lying in the same part of a similar general series of strata, and containing similar kinds of fossils grouped in a similar manner—were of approximately contemporaneous origin. In several of these cases they have a similar base of metamorphic rocks, and a similar cover of Devonian or Carboniferous rocks,—all circumstances giving independent testimony to the truth of our general conclusion. We might further confirm it by the evidence of displacements of the strata, at definite epochs and through definite groups of the strata—movements which have raised the Silurians before the date of the coal, and remodelled the whole area of the land and sea before the Trias and after the Chalk.

It has, indeed, been objected that this conclusion is illogical—that identity of time cannot be inferred from similarity of conditions—that the successive conditions of Silurianism, Devonianism, &c., may be due to a necessary sequence in the order of natural phenomena, and may have commenced *at any time*, round any land which, by rising from the deeps of the ocean, came within the zone of light and life in the waters. The objection is not valid. The dates of the uprising of land are, indeed, as here suggested, various; but according to the period when each came under the influence of the conditions requisite for life are the deposits and the fossils which surround it. An elevation which can be proved to have happened after the Coal is followed by shore- and sea-deposits having the fossils of the period, not the primeval fossils: the land which is raised bears the vegetation of the period, not the primeval vegetation. Thus the series of strata and of fossils, taken as a whole, is but one —a function of the elapsed time; but the terms of the series appa-

there is a strange misplacement at the foot of the page, of the words "and of marine or mostly marine origin." They should have been on page 90, so as to include the beds which follow on that page as marine. The sense is totally confused by this mishap.

* *Heliolites porosa* occurs in the limestone of North Somerset as well as in the limestones of Devon and the Niagara Limestone of New York. *Atrypa aspera*, which was found by Capt. Maclure at Princess Royal Islands, occurs also in the limestones of the Eifel and Devonshire, and in the Niagara group of the New World.

rent at any place depend on the physical history of the locality—a function of local conditions. In other words, the agreements depend on concurrence of time; the differences on disagreeing local conditions.

The correspondence in time here indicated by the term contemporaneity may be understood as having only so much of definiteness as belongs to the deposition of a stratified rock. Whatever phenomena occurred within the limits of the duration marked by the beginning and ending of such a deposit may be reckoned as of *one period*, though they may not all be assignable to one precise or momentary *epoch*. There are good reasons for doubting the exact *epochal* correspondence of distant parts of the same continuous sedimentary deposits (as, for example, in beds of obliquely laminated oolite and millstone-grit, in which the successive deposition of parts of the bed by currents flowing in ascertained directions is certainly traced), but none which forbid our using these deposits to mark a *period* having a certain place in a series of periods*.

Geology has thus obtained a true scale of relative time on which to register all the events in the earth's history which fall within the wide compass of her inquiry. Starting with a scale of strata exactly determined, and rendered as perfect as possible in one basin, we acquire a general series or scale of deposits, in the order of their deposition, suited to a certain area of the ancient bed of the sea. By examination of these deposits, we find in each of them fossil marks of an intelligible kind, by which the place of any given step in the series can be determined for the area in question. By comparison of one large basin of strata with another, it is found that the fossils taken in allied groups have larger ranges than the mineral or structural characters of the strata, and indicate that the basins were occasionally, or frequently, in communication, so that some corresponding forms of life are found to occur in both, in several or all of the deposits, and in the same order of succession.

By thus comparing basin with basin, it is found that hardly one of the stratified systems of rocks was so insulated by the circumstances of its formation as to show no conformity with another in the sequence of ancient life, however different may be the appearance and however unequal the completeness of the series of the groups of strata. If there were any seas entirely separated (as now we see the Caspian and other seas), the separation of them must have taken place at some definite period, previous to which they were influenced more or less by the general order of life in the other neighbouring parts of the ocean. It may be taken as a general result of all this inquiry, that there is but one general series of life represented in a fossil state,—each term of this series corresponding to a geological period, and, taken in a large sense, preserving one main or general character, amidst many local variations, over all the areas yet investigated.

* Mr. Godwin-Austen has bestowed much attention on this subject. See also, in my Treatise on Geology in Cab. Cycl. vol. ii. chap. vi., a discussion on this subject, and a diagram in illustration.

Qu

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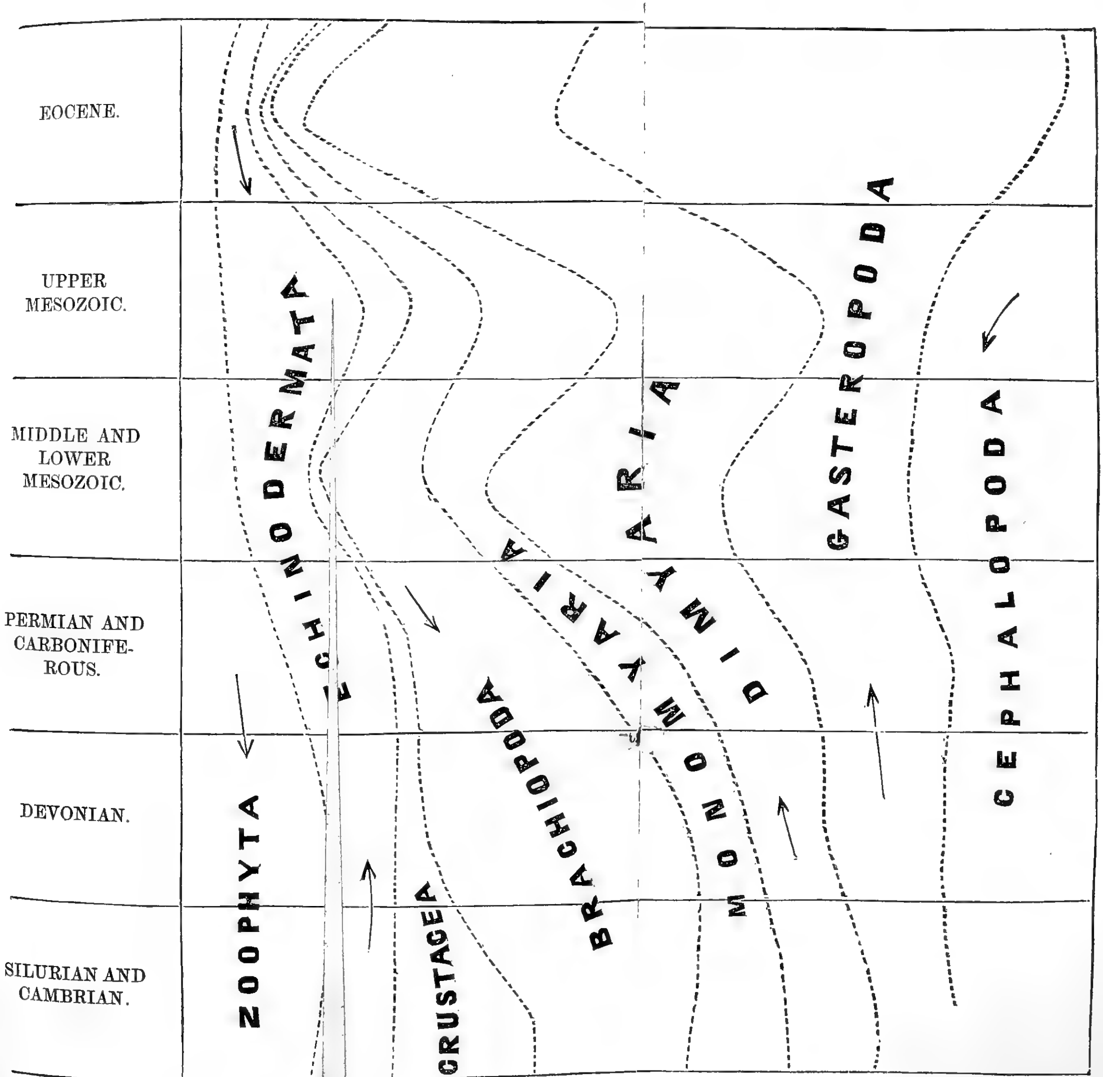
TABLE OF THE DISTRIBUTION IN TIME OF CERTAIN CLASSES OF MARINE INVERTEBRATA.



The conformity of which we here speak is sometimes of such a kind as to be expressed by the term "identity of species," more frequently by the near resemblance of forms in the same genus, for which the name of "representative species" has been employed by E. Forbes. The term species is and must remain somewhat ambiguous in palæontology while the observers of different regions prefer the inglorious task of inventing new names for their native fossils, instead of the useful labour of a strict comparison of them with sufficient examples of the species already described by foreign naturalists. But there is seldom any ambiguity in a generic term; and in each region we can at least *count* the specific forms, or what are considered to be such. This being done, we gain at once a power of numerical expression for the several groups which compose the system of life of each period in each region, or what is preserved of each system, and a representation of the associated life, independent of the particular determinations of the specific elements.

Let us see the effect of such a method tried, in the systems of strata in Britain, on the invertebrate groups of marine life. Taking 1000 for the sum of the species, and confining our computations to large groups including several or many genera and species, we obtain the following tabular numbers‡, which represent the proportionate prevalence of each of the selected classes in each great selected period.

	Zooph.	Echin.	Crust.	Brach.	Mon.	Dim.	Gast.	Ceph.
Eocene	32	28	13	3	52	*277	*†578	16
Cretaceous	35	*163	53	80	*166	†213	125	165
Oolitic and Triassic	55	76	15	74	126	†340	212	*190
Permian and Carboniferous	107	116	33	173	105	151	†178	126
Devonian	*167	54	38	*†302	54	96	140	143
Silurian and Cambrian	157	64	*168	†237	44	116	110	103

[Asterisks are affixed to the numbers which are maxima in each class; † indicates most abundant group in each system.]

The preceding Table and the annexed Diagram represent to the eye the relative prevalence of the several classes selected, in the systems of strata named.

§ *Physiological Relations.*

Among the laws which appear most general as guiding the relations of living beings, is that which expresses the reciprocal dependence of animals and vegetables upon the atmosphere. Every plant and every animal depends upon the free atmosphere, or upon the atmospheric elements absorbed by water; but this dependence

‡ The numbers in each group may be taken from Morris's Catalogue, equating the sum to 1000. This method was much employed by me in collecting the results of my surveys in Devonshire (1839, &c.), for the Palæozoic fossils of that county (1841); again in the Memoirs of the Geol. Survey, Malvernia (1844); and in my Guide and Manual of Geology (1834–1855).

is of such a kind that one absorbs the carbonic acid which the other rejects, one restores the oxygen which the other takes away. This reciprocity, considered in regard to the sea, is more important than in respect of the free air. Without marine plants it is almost inconceivable that the respiration of marine animals would be provided for, especially in the deeper and more tranquil parts of the water. We may consistently believe—and observation appears to justify the belief—that in no period within the reach of Palæontology were marine plants wanting, except in the parts of the ocean so deep that air and light and motion are very feeble in their influence. In marine plants we have one long series of very analogous forms from the earliest periods, corresponding to the uniformity of the conditions of their life. Another law very frequently traceable in existing nature is found in the reciprocity of herbivorous and carnivorous races, by which, in connexion with plants, a complete circle of growth and sustenance is established on the earth and in the water—commencing with the atmosphere as the food of plants, these contributing to the nourishment of half the animal world, which in its turn sustains the flesh-eating races. This dependence is of such an order that the herbivorous races may be conceived to exist without any carnivora, but not the converse, and that one race of herbivora may be balanced by one or another or a mixture of several carnivorous tribes suited to the same element. In looking at the scale of ancient life in the sea we shall find it preferable, in the first instance, to separate the tribes which, like the Brachiopoda and Lamellibranchiata, are nourished by Infusoria coming to their feeding-organs with currents of water. So simple and easy a nutrition seems to warrant the expectation that they were less liable to great variation of type than carnivorous and even herbivorous races, whose life is more varied and more dependent on the changes of external conditions. Let us consider these points in regard to the marine races whose remains are found fossil. Few tribes offer in this respect a more remarkable contrast than the Brachiopoda as Infusorial feeders, and the Gasteropoda, which as a class may be regarded as one-half herbivorous and one-half carnivorous*. The Brachiopoda counted by genera diminish almost regularly with the lapse of time, from 18 Silurian genera to 2 Eocene; while the Gasteropoda commence with 18 Silurian, and augment to 78 or more Eocene. Again, if we separate the Gasteropoda into two groups, the Herbivora commence with 18 Lower Palæozoic, and go on augmenting to above 50 Eocene genera, while the Carnivora are almost unknown in all the Palæozoic groups, but grow continually in number to nearly 30 of Eocene date. These and some other relations appear in the following Table, which shows further that Monomyaria and Cephalopoda attain a maximum of generic variety in the Mesozoic strata:—

* In the following remarks, the Holostomatous Gasteropoda are counted as herbivorous, the Siphonostomatous genera are included as carnivorous: this classification, though not strictly correct, is the only one applicable to the present purpose.

	Brach.	Monom.	Dimy.	Gast. *a.*	Gast. *b.*	Cephal.	Fishes.
Eocene	2	7	45	51	27	4	60
Cretaceous.........	10	13	44	18	10	*12	45
Oolitic	9	*17	46	37	9	5	49
Carboniferous	15	9	35	20	1	7	60
Devonian	15	3	16	9	0	5	35
Silurian	*18	5	17	18	0	5	4
	Infusorial Feeders.			Herbivorous and Carnivorous.		Carnivorous.	

Some years since (1842-44), while engaged in discussing the large collections of Lower Palæozoic Fossils for my Memoir on Malvern, I found reason to remark on the very limited molluscous fauna of the whole Silurian series in the south-west of Wales,—and in regard to the Conchifera, to remark that in that whole district all the forms appeared reducible to three great families—Aviculaceæ, Mytilaceæ, and Arcaceæ. If we trace in a diagram the geological distribution of these families, it appears that hardly any bivalves, except such as belong to Aviculaceæ and Arcaceæ, occur; Mytilaceæ (with what I regarded as allied forms, viz. Goniophora and Orthonota) abound in the Upper Silurians. Once introduced, these groups never cease to be traceable through all the range of the strata; and some of the genera are continuous even from the Lower Palæozoic to the latest Tertiaries and to the existing ocean. It seems, however, that two at least of these families may be regarded as having passed the maximum. If we compare with these the large groups of Limidæ, Ostræidæ and Trigonidæ, none of which really appear in the Lower Palæozoic strata, we find them to have their origin (with only a doubtful exception in *Limæa*) in the Mesozoic series, to have in that their capital, and to be now reduced to a few representatives in nature. Pectinidæ, on the other hand, exhibit an intermediate character—rising, in the groups above the Silurian, to a maximum in the Mesozoic series, and being still an abundant group in the sea.

In tracing the history of some of these ancient families of Mollusca through the long course of geological time, hardly anything is more striking than the continuity of the character of each family, and the small additions which are made to it by ramifications of any kind. Side by side with them grow up in later ages many other families, as the Cardiaceæ, Veneridæ, Myadæ. These do not appear to replace the older types or to be derived from them, but to take parallel and, it may be said, independent courses, so as to suggest to us, as to our lamented Forbes, the conception of epochs rich in additional generic ideas,—a poetical mode of expression not really clearer or more precise than that of W. Smith, who regarded the life of each natural group of strata as a separate creation—in which he is completely followed by D'Orbigny and a host of modern writers.

If in the same manner we trace the families of the purely carnivorous group of Cephalopoda, the result will be very different. Orthoceratidæ commence in the Lower Palæozoic, and end in the

Triassic beds of St. Cassian; Nautilaceæ begin in the Lower Palæozoic, and are still existing; Ammonitidæ begin with the Upper Devonian series, and cease with the Chalk; Belemnitidæ are of still younger date, first appearing with the Lias, and ending with the Chalk; while the Sepiadæ and Teuthidæ from the same date of origin are continued to the present ocean, with the Argonaut, which is unknown below the Tertiaries. In the case of the *Orthocerata*, which die out and seem to be replaced by *Belemnites*, we have a type of the many successive substitutions which this class of Mollusks exhibits for study.

Thus in the Ammonitaceæ, *Goniatites* is followed by *Ceratites*, this by the *Arietes*, these by the *Falciferi*, these by *Coronarii*, *Macrocephali*, *Dentati*, *Ornati*, *Flexuosi*, &c., which and several other groups occupy definite stages in the Lias, Oolites, and Cretaceous deposits*. The successive sets of forms cannot, I think, be deduced from the preceding ones: yet some real succession appears among the Ammonites—in their sutures, so well examined by Von Buch—and among the Belemnites, of which the Liassic, Oolitic, and Cretaceous groups may be for the most part very well and easily distinguished.

§ *Succession of Life.*

The conclusion, that the most remarkable combinations of the natural objects whose remains are found in the earth depended, like the phases of human society, upon elapsed time modified by local conditions—in this respect also like the changes of the families of mankind,—this conclusion by no means closes the inquiry or solves the problem of life on the globe.

In all parts of nature we perceive, and acknowledge with reverence and delight, the most happy adjustments of structure and function; very often, adaptations of singular beauty to suit residence in air or water; not seldom, special organization and habits fitted for particular works or constructions, or peculiar local conditions. "Commoda quibus utimur, luce quâ fruimur, a Deo nobis dari videmus."

Zoology, botany, and physiology are full of these manifestations of coordination of the structures and functions, of habits of life and physical conditions; and no well-reasoning mind can resist the conviction that the innumerable contrivances and coordinations which are discovered in nature are evidence of a higher power of thought than our own, an unlimited command of those forces of which we can only measure the sensible effect in time and space, and an intentional guidance of the complicated machine of creation by fixed general laws, which hold together in harmony an incalculable variety of variable elements.

Can we discover these laws?

Perhaps not. The process of induction, by which alone we can hope to reach a sure basis of theory, may be incomplete through

* See my Treatise on Geology, 1832, Encycl. Metrop.; also 'Guide to Geology,' and the articles "*Goniatites*" and "*Turrilites*" which I communicated to the 'Penny Cyclopædia.'

want of space enough—for terrestrial physics are bound up with cosmical vicissitudes,—and through want of a sufficiently complete sequence in time; for the "chain of life" (if that be a safe expression) may be so broken by the destruction of links, that no art can reunite it.

Is there such a chain of life in existence? Has such ever existed? Is the actual life of the globe truly descended by ordinary processes from the earlier systems which geology has brought to light, so as in this sense to constitute such a chain?

We may confidently declare that in the actual system of nature no such complete chain can be traced; no possible art of arrangement can present plants and animals in one continuous series from a lower to a higher type. Plants cannot be thus placed alone; animals cannot be so placed. Not even the greater divisions of plants or animals admit of exact collocation in linear series. What we find are groups of allied forms, better represented by circular areas than by straight lines, having analogies which point in different directions,—and combinations of these into families, orders, and classes, through which some general types of structure can be traced, with limited deviations and modifications in all directions, often suited in a remarkable way to the particular destiny of the creatures which manifest them.

The classes or greater types to which we thus refer the largest number of groups of existing nature were the same at all periods when they existed at all—for some of the classes appear to be totally absent from the earliest deposits. Some existing families and orders are unknown in the strata; and some which do occur there are no longer living*. Finally, while several genera of animals have left traces of their existence in every past great geological period, and are still living, many have come into being and have passed away in each successive period,—their places being either left vacant or replaced by others of the same natural family, order, or class, or by some group having other general affinities combined with peculiarities which serve as substitutes for the special functions of the perished races.

The idea of definite general types of structure, represented in all

* Professor Owen has prepared a full classification of fossil reptiles, in 13 orders, of which 8 appear to be extinct, and 5 are both fossil and recent (Rep. Brit. Assoc. 1859). The following brief summary will explain this classification:—

Ganocephala	Carboniferous.
Labyrinthodontia ...	Triassic?
Ichthyopterygia ...	Lias to Chalk.
Sauropterygia	Trias to Chalk.
Anomodontia	Triassic.
Pterosauria	Lias to Chalk.
Thecodontia	Triassic.
Dinosauria	Lias, Greensand.
Crocodilia	Lias to modern seas.
Lacertilia	Oolitic, Cretaceous, Tertiary, Modern.
Ophidia	Tertiary and living.
Chelonia...............	Triassic, Oolitic, Cretaceous, Tertiary, living.
Batrachia	Oolitic ?, Tertiary, living.

periods by forms which are subject to limited modification in each period, rises naturally to the mind as best expressing the actual relations of the world of life—the idea of one great design, reaching through the immensity of time, essentially limited in its expression by selected combinations, but within these limits admitting of a vast variety of adjustments to varying local conditions :—

...... "Quoniam minui rem quamque videmus,
Et quasi longinquo fluere omnia cernimus ævo,
Ex oculisque vetustatem subducere nostris;
Quum tamen incolumis videatur summa manere;"——

§ *Geological Time.*

The earth, then, has a HISTORY—more complete in the sequence and more precise in the knowledge of events than is usually found in the history of any far-descended races of men. We cannot, indeed, marshal the events under letters which shall stand for *anno mundi*; we cannot compute their dates by years and days, by eclipses and conjunctions; and, in this sense, the ancient and the modern history of the world cannot be measured by the same CHRONOLOGY. We cannot know the *antiquity* (that is to say, the date in solar time) of any one ancient horizon of life, or great system of natural agencies. But we are not debarred from computing the *relative lapse of time* among the ancient deposits. The laws of Nature are the same to-day as in the earliest time, however much the conditions may have varied, and the ratio of effects to time may have varied also. If we choose among the conditions those which are least variable, as the mechanical action of water put in motion by declivity of ground or tidal agitation, or wind excited by differences of temperature and changing state of vapour—in a word, the atmospheric, fluviatile, and oceanic agencies by which the earth's surface is wasted in one part and modified by aggregation elsewhere,—we may employ the mean result of these actions as equivalent to a unit of time. And, though it should appear that the conditions assumed as constant were really variable, this variation may have been (or rather must have been) according to a law of gradual change to greater or less, which may become sufficiently known to allow of a probable correction.

The accumulation of strata of a *sedimentary* character, as sandstones and clays, is a result of the kind here looked for, and is applicable to all the groups of strata in which traces of life occur. If the calcareous rocks be included, which were of slower accumulation and from different causes, it will not vitiate the process: limestones being included in each great natural system of strata, our unit of time may be supposed affected by equal errors in all the systems. We may assume any convenient thickness, so as to include the principal varieties of watery aggregates—as limestone, sandstone, clay (reckoning conglomerates with the sandstones, shales with the clays, and chalk with the limestones). Take, then, the unit of thickness such that it shall be $\frac{1}{100}$th of the ascertained strata in which life-traces occur; take the thicknesses of the strata at their maximum

in the British Isles; we shall have the following scale of time against the three great divisions of the stratified rocks*:—

Scale.......................... 100			
			feet.
In which the earliest group occupies 79, the middle group 18, the latest only 3 parts.	3	Cænozoic	2240
	18	Mesozoic	13190
	79	Palæozoic	57154
			72584

From such a diagram immediately arises the important inference, that in the earlier periods of the world's history the changes of life in the sea were accomplished at a rate much less rapid than that which prevailed in later times, which agrees with the acknowledged very wide distribution of palæozoic forms in geographical space. Admitting the changes of life on the whole to be equal from the Palæozoic to the Mesozoic, and from these to the Cænozoic periods, we find the rate of progressive change $\frac{1}{79}$ for Palæozoic, $\frac{1}{18}$ for Mesozoic, and $\frac{1}{3}$ for Cænozoic time,—a conclusion of great importance, and probably indicative of the greater influence and superiority in early times of a slowly changing physical condition of the whole globe over the partial and irregularly varying local conditions, which were continually augmenting and are still augmenting in influence with the lapse of time. Such a superior influence has been ascribed to greater uniformity of terrestrial temperature than is now experienced.

§ *Conversion of Geological into Historical Time.*

It is possible by some hypothesis of the annual waste of the surface of land, or the annual deposition of sediment, as now observed in the sea, at the mouths of rivers or in lakes, to transform the unit of geological time above suggested into an equivalent term of years; but the numbers which result for the age of any given rock, like those which represent the circumference of a circle in terms of its diameter, are usually so large as to elude the grasp of memory or imagination. As an example, let the Wealden group of Sussex be taken, with its thousand feet of deposits of sand, clay, &c., formed by the action of an ancient river flowing through forests of a tropical aspect, and nourishing reptiles of a corresponding character. Let the river be assumed as equal to the Ganges in its power of transporting sediment and in its extent of drainage. The sediments left by such a river at its mouth might amount to a thickness of 1 inch

* The thicknesses are taken from Professor Ramsay's communication to Mr. Darwin.

in a year on a surface of 3000 miles; and therefore 1000 feet of Wealden beds might thus be deposited in 12,000 years.

Again, the Weald of Sussex has been denuded by watery action, and its arch of marine and fluviatile strata cut down on an average about 1100 feet. Supposing the denudation to have been by atmospheric and river action, and at the same rate as the waste of surface in the Gangetic area, we shall find it necessary to give $12000 \times 111 = 1332000$ years for the effect*.

If it be supposed to have been accomplished by the sea cutting its way against cliffs, we may, by assuming this waste equal to the most rapid destruction of any considerable part of our coast ($2\frac{1}{4}$ yards in a year by measure on the Holderness coast), considerably reduce the period. But Mr. Darwin, by assuming a very slow rate of waste (1 inch in a century), augments the time of this operation to the inconceivable number of 306,662,400 years†! To show how little these computations are relied on, it is enough to say that Sir R. I. Murchison does not admit the basis of either, denying the denudation to have been by ordinary atmospheric or ordinary oceanic agencies.

Do not geologists sometimes speak with heedless freedom of the ages that have gone? Such expressions as that "time costs Nature nothing" appear to me no better than the phrase which ascribes to Nature "the horror of a vacuum." Are we to regard as information of value the assertion that millions on millions of ages have passed since the epoch of life in some of the earlier strata? Is not this abuse of arithmetic likely to lead to a low estimate of the evidence in support of such random conclusions, and of the uncritical judgment which so readily accepts them?

Dismissing, then, any further examples of this geological calculus, I may call your attention to one case of recent inquiry bearing on the connexion of geological with historical time.

The River Somme, of historical celebrity, rising near St. Quentin, and flowing by the walls of Péronne and the towers of Amiens, occupies a gentle valley, not 100 miles in the whole length, in the chalk country of Picardy. For a considerable part of this course the valley discloses at intervals deposits of gravel sometimes elevated as much as 100 feet above the river, and 6 to 12 feet thick, covered by whitish marls and sand and unstratified brick-earth. The gravel is irregularly stratified with sand; it consists mainly of small fragments of flint not much worn by attrition, but encloses besides masses of tertiary sandstone comparable to the "greywethers" of Wiltshire, and wedge-shaped masses of flint several inches long, which appear to have been shaped by art, for purposes of digging earth or scraping wood, or less peaceful occupations. The gravel-deposit appears to be of fluvia-

* Within the drainage of the Ganges (300,000 square miles) the average waste of the whole surface appears, by the amount of impurity in its waters, to be $\frac{1}{111}$th of an inch annually.

† In this computation there seems an error in principle—viz. that it costs 500 times as long a period to waste a cliff 500 times as high. Cliffs are not wasted in inverse proportion to their height.

tile origin, due to freshwater currents flowing down the valley in some ancient period. It contains land and freshwater shells of species now living, and in some places bones of Elephant, Rhinoceros, Hippopotamus, Cervus, Bos, Equus; so that here appear in one deposit bones of various mammals, some of them extinct, and what appear to be the instruments employed by a being of intelligence superior to theirs, however inferior to that which we recognize even among the rudest tribes of mankind. Of these flints very large numbers have been collected since 1849, when M. Boucher de Perthes first made them known at Abbeville, in his work entitled 'Antiquités Celtiques,'—several of them collected by the personal exertions of the many geologists who have visited the localities. Among these our own Prestwich is pre-eminent, alike distinguished for extensive and accurate knowledge of gravel-deposit. At St. Acheul, near Amiens, passing downwards from the brick-clay, 10 to 15 feet thick, in which appear many old tombs and some coins, he found whitish marl, sand, and small fragments of chalk, with land and freshwater shells (all of recent species) (mammalian teeth and bones are also occasionally found), 2 to 8 feet; and under this, 6 to 12 feet of coarse subangular flint-gravel (with ochreaceous seams), tertiary flint-pebbles, and small sandstone blocks; remains of shells of land and fresh water in patches of sand; teeth and bones of *Elephas primigenius*, Horse, Ox, and Deer, generally near the base. In the lower part of this bed, 17 or 20 feet from the surface, are found the flints which are regarded as rude works of art.

At Menchecourt, near Abbeville, under 2 to 12 feet of brown sandy clay, with angular fragments of flint and chalk-rubble, appear light-coloured sandy clay, with land shells of existing species (and it is said, "flint axes and mammalian remains" occasionally occur), 8 to 25 feet; next white sand: land and freshwater shells abound in this bed, which is from 2 to 6 feet thick, and contains remains of *Elephas primigenius*, *Rhinoc. tichorhinus*, *Bos*, *Cervus*, *Ursus*, *Hyæna*, *Felis*, *Equus*, and, it is said, flint implements. At the base, and forming part of the bed, is a layer of 1 to 2 feet of subangular flint-gravel. Amongst these flints are some marine shells mixed with freshwater kinds; above them lie most of the bones, and, it is said, the greater number of the worked flints. At the bottom is light-coloured sandy marl, with land shells. This occurrence of marine shells was naturally to be expected in the part of the valley near the sea, without supposing any remarkable change of level of land. The flint implements wear a different aspect in the different sorts of deposit which enclose them—being pure and bright in the clean sandy parts, but ochre-stained and dull in the ferruginous gravel, and coated with carbonate of lime where calcareous solutions have affected the unworked flints. In fact, "the flint implements form just as much a constituent part of the gravel itself—exhibiting the same later influences, and in the same force and degree—as the rough mass of flint fragments with which they are associated *."

* Prestwich, in Royal Soc. Proc. 1859.

From these facts it has been concluded that the mammalian bones and the worked flints were deposited in and with the gravel by natural operations; that the extinct mammalia named were coeval with some race of beings which occupied that district, and have left this, but no other, proof of the possession of a rude kind of art and a low degree of intelligence. If we must ascribe these flint instruments (which seem inferior even to the specimens of Australian art) to the agency of the children of Adam, geological time, marked by the extinct mammalia, seems to be at last joined, though not clearly, to the human period, but not with any known data of properly historic time.

A result so interesting cannot be received without prudent hesitation and the hope of more complete evidence, not confined to one bed of gravel. Still, results in this direction could not be wholly unexpected. *Elephas primigenius* had its hair still attached to the skin in the ice cliffs at the mouth of the Lena. *Bos longifrons* is an extinct species, but it survived to be found among the reliquiæ of our own British ancestors, in their places of sepulture*. The Irish Elk and *Hippopotamus major* have been often found in lacustrine deposits and peat-bogs of post-glacial date†. Of the latter animal, three skeletons in admirable preservation were taken from the alluvial sediments in the valley of the Aire,—sediments which lower down the valley yielded, at the bottom, Red Deer and petrified hazel-wood; above these, the oars of an ancient oak canoe; and higher still, but yet several feet below the surface, the coin of an English king.

Here seems to be a continuous river-action from the period of the Hippopotamus to the present day—following the same declivities, broken by no convulsion, marked by no great physical change. The valley-deposits of Amiens and the Somme, like those of Oxford or Reading and the Thames, have a distinct relation to the general configuration and slopes of the land, and in this sense, as well as in the character of the organic contents, must be referred to the latest of the geological periods. How much of analogy exists between the main characters of the gravel of the French and the English valleys, and how much of interest belongs to many almost unexamined fluviatile deposits of old date, may be illustrated by some observations which I made a few years since near Oxford.

At Yarnton, a few miles north of Oxford, the valley of the Thames expands so as to unite with that of the Cherwell; and here a very large deposit of gravel occurs, under some considerable depth of surface-soil. Opened for the works of the railway, it was found to yield teeth and tusks of *Elephas primigenius*, bones of men, and ancient pottery. On visiting the spot I found about 16 feet of ground excavated. At the bottom, Oxford clay; on this a hard bed of the glacial drift, with boulders and fragments compacted together, chiefly of the quartzite so common in this drift near Oxford; on the top and cemented to this bed were many teeth and tusks of

* Owen is the authority for this statement.
† In North Lancashire.

the Elephant; above lay an irregular series of gravel, sand, and loam, in many incomplete layers (elsewhere containing land shells drifted), and some darker parts irregularly traceable upwards. These being accurately examined, were found to be old pits, partly full of dark earth, old British pottery, and human bones. They were places of sepulture, a few feet deep; but it required careful eyes to discern the original limits, which time had rendered obscure:

... "tantum longinqua valet mutare vetustas."

This ground had been traversed by Charles I., retiring by night from Oxford and the Parliamentarians, and little heeding the memorials of earlier fights beneath his feet. What a succession of periods is here offered to the mind in one opening 16 feet in depth! What errors might not be perpetuated in our books by a mere indiscriminate gathering of the spoils of one pit—spoils of historic, pre-historic, and pre-Adamitic time, always truly distinguished by Nature, though confused by heedless collectors.

Nor is it only in the collection of specimens that we are liable to errors of neglect. When the collections come to our hands, how often must we deplore the deficiency of authentic information, the want of localities, the want of sufficient examples for study! When cabinets change hands, how many things become mixed which should have been kept asunder! how many things lose their history, because the mind which alone preserved it has passed away! If, through the lapse of time, our own collections have begun to wear in places this doubtful aspect, let us rejoice that there still remain amongst us a few of our earliest friends who remember the objects for which these collections were formed, and retain a strong desire to provide for their fulfilment. Already the necessary labour of revision and re-arrangement is begun; progress is already made; our thanks are already due. By the election this day of Mr. Leonard Horner as your President, you have taken the course at once most useful to the Society and most agreeable to its feelings. You thus express to him the respect and affection which a long life of devotion to science and to this Society naturally engenders, and you encourage him to persevere in a labour which few could undertake with so good a hope of successful results. I trust that, when his term of office expires, he will experience the gratification which I now feel in acknowledging the kindness and forbearance which have sustained me in the discharge of my duty, supplied all my shortcomings, and enabled me happily and thankfully to resume my place among the friendly members of a zealous, united, and prosperous Society.

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OF

THE GEOLOGICAL SOCIETY.

April 6, 1859.

James Phillips, Esq., Claremont Lodge, Brixton Road; Charles Gould, Esq., B.A., Geological Survey of Great Britain; John Edward Lee, Esq., Priory, Caerleon, Monmouthshire; and John Leckenby, Esq., Scarborough, Yorkshire, were elected Fellows.

The following communication was read:—

On the Subdivisions *of the* Inferior Oolite *in the* South of England, *compared with the Equivalent Beds of that Formation on the* Yorkshire Coast. By Thomas Wright, M.D., F.R.S.E., F.G.S.

Contents.

C. Section from the Cornbrash to the Millepore-bed in Gristhorpe Bay, Yorkshire.
D. Sections in Somerset and Dorset, (1) Glastonbury Tor, (2) Yeovil, (3) Henbury, (4) Half-way House, near Yeovil, (5) Bradford-Abbas, Dorsetshire.

3. The zone of *Ammonites Parkinsoni.*
A. Section at (1) Leckhampton Hill, (2) Ravensgate Hill, (3) Cold Comfort, (4) Birdlip Hill, (5) Rodborough Hill.
B. Sections at Dundry, Bath, Yeovil.
C. Sections near Bridport.

§ IV. Conclusion.

§ I. *Introduction.*—The researches necessary to determine with accuracy the range and distribution of the *Echinodermata* in time and space, for my monograph on the Oolitic species of that class, necessitated a like inquiry into the history of the *Mollusca* associated with them in the same beds. This study has led to a closer inquiry into the subdivisions of the Oolitic Rocks in the South of England and on the Yorkshire Coast, with the view of reconciling or explaining certain real or apparent exceptions to the distribution of the species in their different stages. The result of these investigations has been the accumulation of a large quantity of materials, a *résumé* of a portion of which, relating to the Inferior Oolite, I purpose giving in this memoir.

The study of the Oolitic rocks, during late years, has largely engaged the attention of English and Continental geologists; and the united labours of so many competent observers in different lands have brought to light many new and important facts, which have shown how much still remains to be done to complete the history of the Jurassic formation.

Nor are the results of such investigations limited to a knowledge of these formations only; for a more accurate examination of the stratigraphical conditions under which the Jurassic rocks were deposited, and a more critical acquaintance with the specific distinctions of their different faunas, will enable palæontologists to apply the knowledge thus acquired to the solution of other problems in geology. For in many respects the Jurassic series, as developed in England, affords a better field for accurate investigation than any other system of stratified rocks, inasmuch as its various stages and their stratigraphical sequence, taken as a whole, are more complete, more regular, and better exposed; the different faunas, likewise, of their various subdivisions have not only been collected with care, but separate monographs on different classes of the *Invertebrata* have been published by the Palæontographical Society:—on Corals, by Professor Milne-Edwards and M. J. Haime; on Brachiopoda, by Mr. Davidson; on the Mollusca of the Great Oolite, by Professor Morris and Mr. Lycett; on the Echinodermata, by myself; to which may be added the Description of the Fossil Insects of the Secondary Rocks, by the Rev. P. B. Brodie. The small number of palæontologists, who practically study the distribution of species in time, compared with the large number of geologists, who delight in wider and more superficial studies, has led to misunderstandings between these two classes of observers, injurious to the progress of

our science,—the palæontologist asserting that, when species are critically studied, they are found to have a limited range in time—the geologist arriving at an opposite conclusion. Palæontologists are thus said to draw hard lines in the study of the stratified rocks; whilst geologists attempt to shade off these lines, by asserting that species blend together in certain so-called passage-beds.

These questions can only be settled by *accurate observation* and a *rigorous determination* of the *specific characters of the fossils imbedded in each superimposed stratum.* When such an examination of all the classes shall have been made, the comparative value of the conclusions of the palæontologist and geologist will be fairly tested; it will then, I venture to predict, become evident how defective most of the lists of species in the infancy of our science have been, and what an immense progress has been made by such special critical studies. It is with the view of contributing my small mite to this good cause, that I have drawn up with care lists of fossils from the different zones of the Inferior Oolite for this memoir, with the intention of proving that each of the subdivisions of that formation contains certain species which are special to it, with others that have a wider distribution.

The thinning out of the zones in limited geographical areas, and their absence in others, are facts which have been much overlooked, and readily explain the presence or absence of intermediate beds in certain localities, and the greater or less development of the same at other places, constituting no deviation whatever from those laws which regulate the distribution of species in time and space.

§ II. *The Cephalopoda-bed at Blue Wick, near Robin Hood's Bay, Yorkshire.*—In excursions made, in the summers of 1858 and 1859, to Stainton-dale Cliffs and the Peak, I had the satisfaction of finding the true equivalent of the Cephalopoda-bed and sands at Blue Wick, near Robin Hood's Bay, beneath a rock which I consider the basement-bed of the Dogger, or Inferior Oolite—a yellowish sandstone, containing several seams of small round pebbles, which lie near the bottom. The pebbly conglomerates are about four inches in thickness, and recur at intervals. The sandstone contains fragments of *Belemnites*, *Cerithium*, and *Monotis nitescens*, Simpson. The bed is about five feet, and rests on No. 1, a band of dark friable shale, resting on a hard ironstone-band, full of fossils. This bed is very micaceous in parts; and many of its shells are stained with peroxide of iron. I found clusters of *Terebratula trilineata*, Young & Bird, in the sandstone, with *Belemnites compressus*, Voltz, *B. irregularis*, Schloth., *Trigonia Ramsayii*, Wright, and *Rhynchonella cynocephala*, Rich. The same species occur in a ferruginous seam of sandstone at Glaizedale. This bed is about eighteen inches thick, and rests on No. 2, *The Yellow Sandstone*, which is well exposed at Blue Wick. It consists of irregular layers of soft yellow sandstone, unequally indurated: some portions weather out and leave hollows in the cliff; others are fine-grained, yellowish, highly micaceous, thick-bedded, and variously jointed. The upper part of this rock is

ochraceous, and contains seams of shells (*Turritella*, *Trigonia*, and *Astarte*); one large block contained fragments of *Ammonites inornatus*, Will. (=*A. insignis*, Schlüb.), *Ammonites Comensis*, v. Buch, *Goniomya angulifera*, Sow., and two species of *Crustacea* (*Glyphæa*, n. sp., and *Glyphæa Birdii*, Bean); the bed is about twenty feet thick.

No. 3, *the Serpula-bed*, a fine-grained greyish-yellow sandstone, which forms a reef, dips gently to the south-east, and presents a low escarpment to the north: it is regularly jointed; and its exposed upper surface contains masses of *Serpula*, *Vermetus compressus*, Will., *Serpula diplexa*, Bean, *Pecten intercostatus*, Wr. n. sp., *Ammonites Aalensis*, Ziet. (var. *Moorei*, Lyc.), and a new and remarkable species of *Pseudodiadema*, belonging to the group *tetragramma*. The upper portion of the bed, which is most fossiliferous, is four feet thick; the lower portion, about six feet thick, contains the same species of fossils, but fewer in number.

No. 4, *the Lingula-bed*, or Grey Sandstone, is a soft argillo-micaceous sandstone, in parts fissile, and having a bluish-grey colour. This rock is divided by long joints, and forms "scars" at Blue Wick. Its upper, fissile portion is fossiliferous, and contains *Lingula Beanii*, Phil., *Orbicula reflexa*, Sow., and *Monotis nitescens*, Simp. About the middle of the bed a layer of small nodules occurs; fragments of *Crustacea* (*Glyphæa Birdii*, Bean, and *Glyphæa*, n. sp. allied to *G. rostrata*) are obtained from these nodules. The lower portion is rough and sandy, and passes into hard, argillaceous, nodular layers. The following species are obtained from the sand:—

Ammonites Aalensis, *Ziet.*
—— Comensis, *v. Buch.*
Belemnites compressus, *Voltz.*
—— irregularis, *Schloth.*
Alaria, n. sp., allied to *A. Phillipsii*, Lyc.
Cerithium quinquepunctatum, *Deslong.*
—— vetustum, *Phil.*
Mytilus scalprum?, *Sow.*
Pecten Wickensis, *Wr.* n. sp.
Goniomya angulifera?, *Sow.*
Pholadomya fidicula, *Sow.*
—— obliquata?, *Phil.*
Monotis nitescens, *Simp.*
Lingula Beanii, *Phil.*
Rhynchonella cynocephala, *Rich.*
Orbicula reflexa, *Sow.*
Terebratula trilineata, *Young & Bird.*
Glyphæa Birdii, *Bean.*
——, n. sp., allied to *G. rostrata.*
Pseudodiadema Wickense, *Wright*, n. sp.

The hard grey argillaceous nodules which lie at the base of the sand and rest upon the Alum-shale have hitherto been referred to that formation. This band of rock, however, contains certain species of *Ammonites* which are not found in any other stratum on the Yorkshire coast; and it undoubtedly represents the lower series of fossiliferous nodules which lie near the base of the Lias-sands in Gloucestershire. The following species have been collected from the grey nodules:—

Ammonites Jurensis, *Ziet.* (gubernator, *Simp.*).
—— insignis, *Schlüb.*
—— obliquatus*, *Young & Bird.*
—— Beanii, *Simp.*
—— Aalensis, *Ziet.*
Ammonites striatulus, *Sow.*
Monotis nitescens, *Simp.*
Goniomya, n. sp.
Orbicula reflexa, *Sow.*
Lingula Beanii, *Phil.*

* *Ammonites obliquatus* and *A. Beanii* only represent different ages of the same species, which is the *Ammonites variabilis*, d'Orbigny.

Tabular View of the General Section of the Inferior Oolite (beneath the Fuller's-earth with Ostrea acuminata) *in the South of England; showing the Order of Superposition, Classification, and Type-localities of the different Beds described in this Memoir.*

Zones.	Beds and Leading Fossils contained therein.	Districts and Type-localities *. Cheltenham.	Stroud.	Bristol.	Yeovil.	Bridport.
Zone of *Ammonites Parkinsoni.*	*a.* Upper Trigonia-grit, with *Ammonites Parkinsoni, A. Martinsii, A. Truellei, A. subradiatus, Homomya gibbosa, Ceromya plicata, Trigonia signata*	Leckhampton. Cowley. Cold Comfort.	Rodborough. Scar-hill.	Dundry. ...... Widcombe-hill.	Half-way. Bradford. Henbury.	Burton. Walditch. Chideock.
	b. Gryphite-grit, a local oyster-bank, with *Gryphæa sublobata, Pholadomya Heraulti, Hyboclypus caudatus*	Leckhampton. Cleeve.	Rodborough. Stroud.			
	c. Lower Trigonia-grit, with *Clypeus Plotii, Echinobrissus clunicularis, Hyboclypus gibberulus, Corbicella complanata.* These species appear in this bed for the first time...	Leckhampton. Ravensgate. Birdlip.	Rodborough. Scar-hill. Selsey.	Dundry.	....	Burton. Walditch. Chideock.
	d. Thin marly band, with *Chemnitzia procera*	Ravensgate.				
	Brown micaceous sands, with layers of concretionary sandstone	......	Uley.	Bath.	Yeovil.	Burton.
	e. Fossiliferous band, with *Ammonites Jurensis, A. insignis, A. radians,* and most of the *Conchifera* of *a*	......	Nailsworth. Brimscombe.	?	?	?
	Clays of the Upper Lias, with *Ammonites bifrons, A. serpentinus, A. communis, A. fibulatus*	Leckhampton. Shurdington.	Stroud. Nailsworth.	Bristol. Glastonbury.	Yeovil. Ilminster.	?

In this table I have enumerated only a few type-localities; their number may be increased considerably in each district.

The dark-grey calcareo-argillaceous nodules rest on the clays of the Upper Lias or true Alum-shale, containing *Ammonites crassus*, Phil., *A. communis*, Sow., *A. fibulatus*, Y. & B., *Nucula ovum*, Sow., and *Trigonia literata*, Phil.

Professor Williamson * has truly observed, in reference to this bed, "the top of this shale at Peak Hill appears to contain *Ammonites striatulus*, Sow., enclosed in indurated masses; and I am not aware of its having been met with at any other locality. It occurs so near the top [of the shale], that doubts are entertained whether it belongs to the Alum-shale or to the overlying Inferior Oolite." A careful examination of the lithological character of these argillaceous nodules will enable a practised eye to distinguish their matrix from that of the Alum-shale with which they have been confounded.

A geologist who has studied and compared the Cephalopoda-bed and Liassic Sands †, as developed at Nailsworth, Haresfield, Frocester, Cam-Long-Down, Uley Bury, and Wotton-under-Edge in Gloucestershire, cannot fail to observe the similarity of these deposits to the yellow and grey sands and argillaceous nodular basement-bed, which lie between the Dogger and Alum-shale at Blue Wick, and of which they are the true equivalents ‡.

§ III. *The Inferior Oolite of the South of England, and of Yorkshire.*

1. The Zone of Ammonites Murchisonæ.

Synonyms.—"Dogger" (part), Young and Bird, 'Geol. of the York. Coast,' p. 120, 1822; John Phillips, 'Geol. of York.' p. 38, 1829; "The Central and Lower Division of the Inferior Ooolite," Murchison, 'Geol. of Cheltenham,' p. 10, 1834; "Fimbria-stage of the Inferior Oolite," Lycett, 'Cotteswold Hills Handbook,' p. 34, 1857; "Zone of *Ammonites Murchisonæ*," Wright, 'Monogr. Ool. Echinodermata,' 1856.

Foreign Equivalents.—"Brauner Jura β," Quenstedt, 'Flözgeb.' p. 538, 1843; "Calcaire lædonien" (part), Marcou, 'Jura salinois,' p. 70, 1846; "Calcaire à entroques" (part), Cotteau, 'Bullet. Soc. Géol. France,' p. 638, 1851; "Brauner Beta," Quenstedt, 'Der Jura,' p. 332, 1858; "Die Schichten des Ammonites Murchisonæ," Oppel, 'Die Juraformation,' p. 326, 1856.

Description.—This zone attains a considerable development at the western limits of the Northern Cotteswolds, where it consists of thick-bedded oolitic limestones, resting on coarse calcareo-siliceous ragstones containing a large per-centage of the peroxide of iron,

* Trans. Geol. Soc. ser. 2. vol. v. p. 227.
† See Quart. Journ. Geol. Soc. vol. xii. p. 292 *et seq.*
‡ The reader may consult with profit a paper by my friend John Lycett, Esq. on the sands intermediate to the Inferior Oolite and the Lias of the Cotteswolds, compared with a similar deposit on the coast of Yorkshire, in the Annals and Mag. of Nat. Hist. for Sept. 1857.

[Quart. Journ. Geol. Soc. vol. xvi.: To face p. 5].

Tabular View of the General Section of the Inferior Oolite (beneath the Fuller's-earth with Ostrea acuminata*) in the South of England; showing the Order of Superposition, Classification, and Type-localities of the different Beds described in this Memoir.*

Zones.	Beds and Leading Fossils contained therein.	Districts and Type-localities *. Cheltenham.	Stroud.	Bristol.	Yeovil.	Bridport.
Zone of *Ammonites Parkinsoni.*	*a.* Upper Trigonia-grit, with *Ammonites Parkinsoni, A. Martinsii, A. Truellei, A. subradiatus, Homomya gibbosa, Ceromya plicata, Trigonia signata*	Leckhampton. Cowley. Cold Comfort.	Rodborough. Scar-hill.	Dundry. ...... Widcombe-hill.	Half-way. Bradford. Henbury.	Burton. Walditch. Chideock.
	b. Gryphite-grit, a local oyster-bank, with *Gryphæa sublobata, Pholadomya Heraulti, Hyboclypus caudatus*	Leckhampton. Cleeve.	Rodborough. Stroud.			
	c. Lower Trigonia-grit, with *Clypeus Plotii, Echinobrissus clunicularis, Hyboclypus gibberulus, Corbicella complanata.* These species appear in this bed for the first time...	Leckhampton. Ravensgate. Birdlip.	Rodborough. Scar-hill. Selsey.	Dundry.	....	Burton. Walditch. Chideock.
	d. Thin marly band, with *Chemnitzia procera*	Ravensgate.				
Zone of *Ammonites Humphriesianus.*	*a.* Thin-bedded oolite, overlying an indurated marl, with *Terebratula Phillipsii*	Cleeve.	......	Dundry.	Bradford.	Walditch.
	b. Ferruginous oolite, with *Chemnitzia Sæmanni*	Cleeve.				
	c. Ammonite-bed, an ironshot oolite, with *Ammonites Brocchi, A. Humphriesianus, A. Blagdeni, A. Braikenridgii, A. concavus, A. Dorsetensis, A. Sowerbyi*	Cleeve.	......	Dundry.	Half-way. Bradford. Henbury.	Burton. Walditch. Chideock.
	d. Shelly ironshot oolite: *Pleurotomaria ornata, Pl. fasciata, Pl. punctata,* &c.; *Lima Etheridgii, Pecten barbatus, Terebratula perovalis, Alaria Phillipsii, Turbo capitaneus* ...	Cleeve.	......	Dundry.	Half-way. Bradford. Henbury.	Burton.
	e. Brown sandy oolite, containing many varieties of *Ostrea flabelloides, O. sulcifera, O. pyxiformis*	Cleeve.	......	Dundry.		
Zone of *Ammonites Murchisonæ.*	*a.* Oolite-marl, a local bed of Coralline origin, containing *Chemnitzia, Nerinæa, Terebratula fimbria, T. carinata, T. submaxillata, Thamnastræa,* and *Isastræa.*	Leckhampton. Cleeve. Seven-springs.	Walls-quarry. Swifts-hill. Sheepscombe.			
	b. Thick-bedded oolitic limestone, building-freestone: fossils in the lower portion; fragments only in the middle and upper divisions of the rock	Leckhampton. Dowdswell. Cleeve.	Painswick. Swifts-hill. Walls-quarry.			
	c. Pea-grit: a coarse ferruginous rock, composed of flattened concretions, with *Ammonites Murchisonæ, Pygaster semisulcatus, Hyboclypus agariciformis, Stomechinus germinans, Terebratula simplex, T. plicata*	Cleeve. Leckhampton. Crickley. Birdlip.				
	d. Coarse ferruginous sandy oolite, with few fossils	Leckhampton.	Frocester.			
Sands of the Upper Lias: Zone of *Ammonites Jurensis.*	*a.* Cephalopoda-bed: a coarse, brown, ironshot oolite, with *Ammonites opalinus, A. Jurensis, A. radians, A. insignis, A. variabilis, Trigonia Ramsayi, Rhynchonella cynocephala, Terebratula subpunctata*	Leckhampton. Crickley. Coopers-hill.	Haresfield. Frocester. Wotton.	Dundry. Bath.	......	Burton.
	b. Brown and yellow sands	Leckhampton.	Frocester.	Bath.	Yeovil.	Burton.
	c. Fossiliferous nodules, containing many of the same fossils as in *a*	....	Wotton. Uley.	Bath.	Yeovil.	Burton. Golden cap.
	d. Brown micaceous sands, with layers of concretionary sandstone	......	Uley.	Bath.	Yeovil.	Burton.
	e. Fossiliferous band, with *Ammonites Jurensis, A. insignis, A. radians,* and most of the *Conchifera* of *a*	......	Nailsworth. Brimscombe.	?	?	?
	Clays of the Upper Lias, with *Ammonites bifrons, A. serpentinus, A. communis, A. fibulatus*	Leckhampton. Shurdington.	Stroud. Nailsworth.	Bristol. Glastonbury.	Yeovil. Ilminster.	?

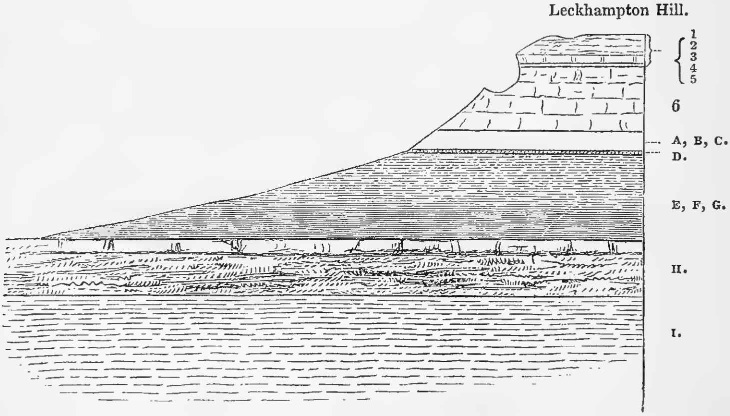
* In this table I have enumerated only a few type-localities; their number may be increased considerably in each district.

and beds of pisolite or pea-grit, strongly impregnated with the same mineral. The freestones are in many places overlaid by a bed of cream-coloured marl, containing a vast quantity of *Terebratula fimbria*, Sow. In the neighbourhood of Cheltenham this zone is well exposed, and here appears to have attained its greatest development. The aggregate thickness of the pea-grit, freestone, and marl is about 190 feet. In the Southern Cotteswolds these beds become gradually thinner the further they are traced southwards; and at Dundry they almost entirely disappear. In the eastern direction the same result is found to exist: at Turkdean, near Northleach, the zone is only about 50 feet in thickness, and at Sherborne about 5 feet; near Burford it has entirely thinned out, and there the Inferior Oolite is represented by the upper ragstones of the zone of *Ammonites Parkinsoni**.

A. *Sections of the Inferior Oolite in Gloucestershire.*

Leckhampton Hill, near Cheltenham, presents one of the most typical sections, in Gloucestershire, of the three subdivisions of the Inferior Oolite, where the following beds are admirably exposed. Beds Nos. 1, 2, and 3 represent the zone of *Ammonites Parkinsoni*; bed 4, the zone of *Ammonites Humphriesianus*; and beds 5, 6, and A, B, C, the zone of *Ammonites Murchisonæ*.

Fig. 1.—*Section of Leckhampton Hill.*



1. Trigonia-bed.
2. Gryphæa-bed.
3. Brown rubbly oolite.
4. Flaggy freestone.
5. Fimbria-bed or oolite-marl.
6. Freestone.

A, B, C. Pea-grit and ferruginous oolite.
D. Cephalopoda-bed.
E, F, G. Upper Lias sand and Upper Lias clay.
H. Marlstone.
I. Lower Lias clay.

* Much valuable information, and many accurate sections, are given in my friend Mr. Edward Hull's excellent memoir on the country round Cheltenham. See 'Memoirs of the Geological Survey,' together with sheet 44 of the Map of the Geological Survey of Great Britain, surveyed by Mr. E. Hull. Consult also M. Triger's memoir on the Inferior Oolite of England, Bulletin de la Société Géologique de France, 2e série, tom. xii. 1854–55, pp. 73–79.

Section I.—Leckhampton Hill, near Cheltenham.

No. 1, *the Upper Trigonia-grit*, is a coarse brown ragstone, containing many fossils,—chiefly (as moulds and impressions) of *Trigonia costata*, Sow.; *Trigonia striata*, Sow.; *Terebratula spinosa*, Schloth.; *Ammonites Parkinsoni*, Sow.; *Clypeus Plotii*, Klein; *Echinobrissus clunicularis*, Lhwyd; *Holectypus depressus*, Leske.—7 feet.

No. 2, *the Gryphæa-grit*, an ancient oyster-bank, composed almost entirely of *Gryphæa sublobata*, Desh.; *Pholadomya Heraulti*, Ag.; *Terebratula Meriani*, Oppel, and other shells.—8 feet.

No. 3, *the Lower Trigonia-grit*, a light-coloured, thin-bedded oolitic ragstone, containing a large assemblage of *Conchifera*, with several species of *Echinodermata* and Corals.

No. 4. Upper flaggy bastard-freestone, well seen above the oolitic marl: 26 feet thick. It represents the zone of *Ammonites Humphriesianus*, but is here almost non-fossiliferous.

No. 5, the Oolite-marl, or Fimbria-bed, is a cream-coloured mud-stone, not unlike chalk-marl. The dominant shell is *Terebratula fimbria*, Sow.: it contains likewise *Lucina Wrighti*, Opp.; *Lima cardiiformis*, Sow.; *L. Pontonis*, Lyc.; *Natica Leckhamptonensis*, Lyc.; *Natica adducta*, Phil.; *Mytilus pectinatus*, Sow.; *Astarte elegans*, Sow.; *Nerinæa* sp., *Chemnitzia* sp., and masses of coral, chiefly *Thamnastræa Mettensis*, Edw.

This bed was deposited under different conditions to that of the freestone on which it rests, as its lower portion is slightly brecciated, and the surface of the limestone on which that breccia rests had been for some time exposed to aqueous action, and worn smooth thereby. The oolite-marl measures about 7 feet in thickness, and passes upwards into a marly limestone, becoming oolitic in the uppermost layers. This division of the bed is about 10 feet thick. The Fimbria-bed is a constant feature in the Inferior Oolite of the Cheltenham district.

No. 6, the Freestone, is a compact light-coloured oolitic limestone. The uppermost beds are the best for building-purposes; the middle beds are of an inferior quality, and stained in part with the peroxide of iron; the lower beds contain large oolitic grains, and are called "roestone." The freestone, in all, is about 110 feet in thickness.

The Pea-grit. (Inferior Oolite.)

		ft.	in.
A.	A brown, coarse, rubbly oolite, full of flattened concretions, cemented together by a calcareous matrix. When the blocks weather, the concretions, which resemble flattened peas, form a very uneven surface. It contains many fossils in good preservation	12	0
B.	A hard, cream-coloured, pisolitic rock, made up of flattened concretions of about the thickness of those in A	10	0
C.	A coarse, brown, ferruginous rock, composed of large oolitic grains: it is readily disintegrated by the frost, and is of little economic value. About	20	0

The Cephalopoda- or Jurensis-bed. (Upper Lias.)

		ft.	in.
D.	A brown marly rock, full of small, dark, oolitic grains of the hydrate of iron, which are strewed in profusion in a calcareous paste. About	2	0
D′.	A thin seam of yellowish sand	0	$1\frac{1}{2}$
E.	A dark-grey crystalline limestone, extremely hard, and resembling some beds of the Carboniferous Limestone; it is bored in different places by *Fistulana*, the shells of which remain in the excavations	0	9
F.	A brown argillaceous sandy bed, full of micaceous particles, passing downwards into fine brown and yellow sands. Thickness unknown.		
G.	Upper Lias Clay, of a dark-blue colour. Thickness probably..................................	160	0

Section II.—Crickley Hill, near Cheltenham.

The Freestone forms a fine bold mural escarpment in this hill, but it is not much worked for building.

The Pea-grit, which is extremely well developed, is extensively extracted for road-material. It admits of the following subdivision:—

		ft.	in.
A.	A coarse oolitic limestone, with large grains and numerous concretionary bodies, extremely hard and crystalline in parts	25	0
B.	A coarse pisolitic limestone, composed of flattened concretionary bodies, which are round, oval, or flattened, like crushed peas	20	0
C.	A coarse brown rock, very ferruginous, and full of large oolitic grains........................	10	0

Section III.—At Beacon Hill, near the Horsepools.

		ft.	in.
A.	A close-grained freestone, resembling the equivalent bed at Leckhampton, but becoming flaggy in its upper part	15	0
A′.	A close-grained yellow oolitic limestone, quarried for road-material, much speckled with dendritical patches of the peroxide of iron, and containing few fossils. It measures........................	12	0
B.	A yellowish sandy rock, separating into large blocks, which contain fossiliferous nodules; the fossils in general are well preserved. It is not used for any economic purpose; and heaps of blocks lie close together by the brown micaceous sands	1	8
C.	A brown sandy oolite, passing into a coarse ferruginous oolite; containing many fossils not well preserved: oolitic grains of the hydrate of iron are scattered through the brown calcareous matrix. It measures from 8 to	10	0

	ft.	in.
A. A fine-grained oolitic limestone, similar lithologically to the freestones of Birdlip, Painswick, and Leckhampton. The upper beds exhibit a remarkable example of oblique bedding, the flaggy layers of which rest horizontally on inclined beds of freestone ..	50	0
B. A coarse, light-coloured, gritty crystalline oolite, traversed at intervals by extremely crystalline shelly layers. A great portion of the rock is composed of fragments of Crinoids, the plates and spines of Echinides, and the débris of the shells of Molluses. This whitish rock has a remarkable lithological character, and glistens brilliantly when the rays of the sun fall on it. The shelly and pisolitic seams which traverse the bed resemble those in the pea-grit, of which it is probably the equivalent	10	0
C. A hard, fine-grained, oolitic sandy limestone, of a light-brown colour. It contains many fossils, which are extracted with difficulty, and passes into a hard yellow oolite with few fossils	10	0

Section V.—At Wotton-under-Edge, near Bradley Turnpike.

This fine section shows the succession of the beds from the Lower Lias to the Great Oolite, inclusive, with all the intermediate strata of Middle Lias, Upper Lias, Jurensis-bed, Inferior Oolite (lower and upper zones), Fuller's-earth, and Great Oolite, as they are exposed between Symonds-Hall Hill, 802 feet above the Severn, and Wotton-under-Edge. My friend Professor Ramsay most kindly prepared this section for me. The hill is capped by the Great Oolite, which rests on the Fuller's-earth; the latter here attains a considerable thickness and overlies the Inferior Oolite.

Fig. 2.—*Diagram showing the Succession of the Strata between Symonds-Hall Hill and Wotton-under-Edge.*

7. Great Oolite.
6. Fuller's Earth; 126 feet.
5. Inferior Oolite limestone; 80 feet.
4. Calcareous hard sandy bands (with specks of silicate of iron), interstratified with softer sand; *Ammonites* and *Belemnites*; 16 feet.
4. Sand of the Upper Lias, with hard sandy lenticular concretions; 123 feet.
3. Upper Lias shale, very thin, with nodules of limestone at the top; about 10 feet.
2′. Hard brown rock capping the terrace; 12 feet } Marlstone.
2. Marlstone; 186 feet........................ } Marlstone.
1. Lower Lias shale and limestone.

		ft.	in.
	Inferior Oolite.		
A.	The limestones of the Inferior Oolite, which form an excellent freestone, very similar to the same rock at Birdlip, Frocester, Painswick, and Leckhampton, have a thickness of	80	0
B.	Is not well exposed in this section; the Inferior Oolite limestone quarry is about half a mile from the section of the lower beds; and the intervening escarpment is covered by vegetation.		
C.	Is represented by a yellow, loose, rubbly oolite, resting on the Cephalopoda-bed; it contains *Ammonites*, other shells, and *Serpula*.		
	The Cephalopoda- or Jurensis-bed.		
D.	A hard, brown, coarse, ferruginous oolitic sandy limestone, speckled with flattened grains of hydrate of iron; the hard sandy bands are interstratified with softer sand, which contains many fossils and passes into		
D[1].	A coarse oolitic rock, not so ferruginous as the upper division, but with fossils of the same species; passing into thin bands of a ferruginous oolite like D.		
E.	A coarse oolitic rock, similar to D[1]; the same bed occurs at Ozleworth and Sudbury. These three beds measure about	16	6
F.	The Upper Lias Sands are yellow and micaceous; they contain inconstant and irregular layers of hard, sandy, lenticular concretions, some of which are fossiliferous. These sands measure............	123	0
	Upper Lias.		
G.	The Upper Lias Clay is very thin, and contains nodules of limestone at the top; it nearly thins out here, as its thickness is only	10	0
	Middle Lias.		
H.	The upper bed of the Marlstone is a hard, brown, calcareous sandstone, which forms the capping of the Marlstone terrace	12	0
H[1].	The Marlstone is well developed, and consists of fox-coloured sandstone, more or less ferruginous, with grey, impure sandy limestone, containing oolitic grains..................................	186	0
	Lower Lias.		
I.	The Lower Lias shales and limestones; thickness unknown.		

The preceding sections exhibit the lithological character and stratigraphical relations of the pea-grit and freestones, which, how-

ever, undergo great and important modifications when examined over even a limited area,—the pea-grit as regards its structure, and the freestone its thickness. In the Southern Cotteswolds the pea-grit loses its pisolitic character; and in the eastern part of the hill-district the freestones thin out and finally disappear,—the Inferior Oolite being represented at Stow-in-the-Wold and at Burford by the zone of *Ammonites Parkinsoni* with its light-coloured ragstones, filled with an abundance of specimens of *Clypeus Plotii*, Klein, and forming a "Clypeus-grit."

a. Fossils of the Pea-grit and the Freestones.—The beds A and B are usually the most fossiliferous. The *Echinodermata* are well preserved in the Pea-grit, and the shells of the *Mollusca* in the Roestone. Many of these are specifically identical with the Molluscan fauna of the Great Oolite. The shells are for the most part small; and the *Anatinidæ*, so abundant in the upper zones, are almost entirely absent from this.

Ammonites Murchisonæ, *Sow.*
Nautilus truncatus, *Sow.*
Belemnites spinatus, *Quenst.*

Patella rugosa, *Sow.*
—— inornata, *Lyc.*
Pileolus lævis, *Sow.*
Nerita costata, *Sow.*
—— minuta, *Sow.*
Monodonta Lyelli, *d'Archiac.*
—— sulcosa, *d'Archiac.*
Natica adducta, *Phil.*
Cirrus nodosus, *Sow.*
Trochotoma carinata, *Lyc.*
Turbo capitaneus ?, *Goldf.*
Trochus monilitectus, *Phil.*
Solarium Cotswoldiæ, *Lyc.*
Nerinæa cingenda, *Bronn.*
Actæonina Sedgvici, *Phil.*

Ostrea costata, *Sow.*
Placunopsis Jurensis, *Roemer.*
Hinnites velatus, *Goldf.*
Limea duplicata, *Goldf.*
Lima sulcata, *Münst.*
—— lyrata, *Münst.*
—— Lycetti, *Wright.*
—— bellula, *Mor. & Lyc.*
Pecten lens ? *Sow.*
Pecten Devalquei, *Oppel* (P. vimineus, *Sow.*).
Mytilus furcatus, *Münst.*
—— striatulus, *Gold.*
Modiola Sowerbyana, *d'Orb.* (plicata, *Sow.*).
Avicula complicata, *Buck.*
Corbula involuta, *Goldf.*
Tancredia axiniformis, *Phil.*
Arca Prattii, *Mor. & Lyc.*
—— pulchra, *Sow.*
—— cancellata, *Phil.*
—— lata, *Dunk.*

Trigonia costata (var. pulla), *Sow.*
—— exigua, *Lyc.*
Astarte interlineata, *Lyc.*
—— rhomboidalis, *Phil.*
Sphæra Madridi, *d'Arch.*
Cyprina trapeziformis, *Roem.*
Unicardium.
Myoconcha crassa, *Sow.*
Ceromya Bajociana, *d'Orb.*
Myopsis rotundata, *Buckm.*
Cardium striatulum, *Phil.*
—— lævigatum, *Lyc.*
Goniomya angulifera, *Sow.*
Pinna cuneata, *Bean.*

Terebratula simplex, *Buckm.*
—— plicata, *Buckm.*
—— submaxillata, *Davids.*
Rhynchonella Wrightii, *Davids.*
—— decorata, *Davids.*
—— concinna, *Sow.*
—— oolitica, *Davids.*

Serpula grandis, *Goldf.*
—— convoluta, *Goldf.*
—— plicatilis, *Münst.*
—— quadrilatera, *Goldf.*
—— flaccida, *Goldf.*

Cidaris Fowleri, *Wr.*
—— Bouchardii, *Wr.*
—— Wrightii, *Desor.*
Rhabdocidaris Wrightii, *Desor.*
Acrosalenia Lycettii, *Wr.*
Pseudodiadema depressum, *Ag.*
Stomechinus germinans, *Phil.*
Polycyphus Deslongchampsii, *Wr.*
Pedina Bakeri, *Wr.*
Hemipedina tetragramma, *Wr.*
—— perforata, *Wr.*
—— Bonei, *Wr.*
Pygaster semisulcatus, *Phil.*

Pygaster conoideus, *Wr.*
Hyboclypus agariciformis, *Forb.*
Goniaster; fragment of a ray.
Pentacrinus; 2 sp.

Montlivaltia Delabechei, *Edw. & Haime.*
—— Waterhousei, *E. & H.*
—— cupuliformis, *E. & H.*
Axosmilia Wrightii, *E. & H.*
Latomæandræa Flemingii, *E. & H.*
Isastræa tenuistriata, *E. & H.*
—— limitata, *E. & H.*
Thamnastræa Mettensis, *E. & H.*
—— Defranciana, *E. & H.*

Thamnastræa fungiformis, *E. & H.*
Stromatopora dichotomoides, *d'Orb.*
Diastopora Waltonii, *Haime.*
—— [illegible]ni, *de Blainv.*
—— Mettensis, *Haime.*
—— Wrightii, *Haime.*
—— [illegible], *Haime.*
[illegible]minea, *Phil.*
Lichenopora Phillipsii, *Haime.*
Neuropora damicornis, *Lamour.*
Heteropora conifera, *Lamour.*
—— pustulosa, *Michel.*
Theonoa Bowerbankii, *Haime.*
Berenicea diluviana, *Lamour.*

b. The Oolite-Marl or Fimbria-bed.—This remarkable bed is a well-marked feature in the Leckhampton Hill section, and forms the uppermost portion of the zone of *Ammonites Murchisonæ*. It is a very persistent stratum in the northern and middle Cotteswolds, and extends across this portion of the plateau from the vales of Moreton and Bourton, on the east, to the mural escarpments of the oolites on the west; but it appears to be absent from the southern part of the range.

The oolite-marl resembles indurated chalk, and, being interstratified between two beds of oolitic limestone, forms a conspicuous feature in the sections where it is so exposed. It rests upon the uppermost bed of the building-freestone, and underlies a thin-bedded oolitic limestone. The marl varies from two to eight feet in thickness, and, when exposed to atmospheric agency, breaks up into cuboidal masses.

This rock appears to have been formed under different conditions to those under which the underlying freestones were deposited: for in some localities it contains masses of coral, chiefly of the genera *Thamnastræa* and *Isastræa*; in others it is charged with immense numbers of *Brachiopoda*, especially *Terebratula fimbria*, *T. carinata*, *T. submaxillata*, and others. In some places it abounds with the long slender shells of *Nerinæa*, forming in one or two localities a "Nerinæan limestone." These palæontological facts lead to the conclusion that this local stratum owes its origin to a coralligenous bank in the oolitic sea. Corals are met with in moderate numbers at Leckhampton near Cheltenham, and at Sheepscombe, and Swift's Hill near Stroud: also in several other places *Thamnastræa* and *Isastræa* abound; whilst in the Cheltenham district the marl contains immense numbers of *Terebratula fimbria*, *T. submaxillata*, *T. carinata*, and *Rhynchonella Lycetti*. At Selsey and Rodborough Hills the marl is represented by a single bed of buff-coloured argillaceous limestone, which contains few fossils and is overlain by a thin-bedded freestone. At Scar Hill near Nailsworth, the representative of the marl contains neither Corals nor Brachiopods, but is charged with long spiral univalves belonging to the genera *Chemnitzia* and *Nerinæa*, with a few *Conchifera* and small *Gasteropoda*. The Nerinæan limestone is a fine argillaceous rock, close in texture, and feebly oolitic, about one foot in thick-

ness. It is overlain by eighteen inches of sandy oolite, which is capped by a compact bed of oolitic limestone, everywhere bored by small vertical tubes of Marine *Annelida*. This rock has yielded most of the *Gasteropoda* which I have collected from the oolite-marl; the fossils are so entirely imbedded in the matrix, that they have to be carved out of the rock. The direct evidence of the existence of *Anthozoa* in considerable numbers, added to the abundance of the spiral univalved *Gasteropoda* (*Nerinæa*) which nestle in coral-formations, together with the indirect evidence of a superabundance of *Brachiopoda*, added to the lithological character of the marl itself, which appears to be the product of coral-mud and other reef débris, leads to the conclusion that the *Oolite-marl* is a portion of a Jurassic coral-bank.

Fossils of the Oolite-marl.

Ammonites Murchisonæ, *Sow.*
Nautilus clausus, *d'Orb.*

Chemnitzia procera, *Deslong.*
Nerinæa gracilis, *Lyc.*
—— Cotswoldiæ, *Lyc.*
—— Jonesi, *Lyc.*
—— Oppelensis, *Lyc.*
—— pseudocylindrica, *Deslong.*
Cylindritis tabulatus, *Lyc.*
—— gradus, *Lyc.*
—— attenuatus, *Lyc.*
Natica canaliculata, *Mor. & Lyc.*
—— macrostoma, *Roem.*
—— adducta, *Phil.*
—— tumidula, *Phil.*
Trachotoma calyx, *Phil.*
—— tabulata, *Lyc.*
—— depressiuscula, *Lyc.*
Trochus monilitectus, *Phil.*
—— pyramidalis, *Phil.*
—— gemmatus, *Lyc.*
—— ornatissimus, *d'Orb.*
—— lamellosus, *d'Orb.*
Monodonta lævigata, *Sow.*
—— heliciformis, *Lyc.*
Cirrus nodosus, *Sow.*
Solarium Cotswoldiæ, *Lyc.*
Neritopsis sulcosa, *d'Archiac.*
—— varicosa, *Mor. & Lyc.*
Nerita costata, *Sow.*
Delphinula funata, *Goldf.*
—— quaterno-cingillata, *Lyc.*
—— Buckmani, *Mor. & Lyc.*
Turbo elaboratus, *Bean.*
Phasianella subangulata, *Lyc.*
Pileolus lævis, *Sow.*
—— plicatus, *Sow.*
Patella inornata, *Lyc.*
Pleurotomaria funata, *Lyc.*
—— lævigata, *Lyc.*
—— sulcata, *Sow.*
Cerithium quadricinctum, *Goldf.*
Fusus, n. sp.

Alaria unicornis, *Lyc.*
—— spinigera, *Lyc.*
—— lævigata, *Lyc.*

Ostrea gregaria, *Sow.*
Placunopsis, sp.
Hinnites abjectus, *Phil.*
Mytilus imbricatus, *Sow.*
—— furcatus, *Sow.*
Plicatula, sp.
Pecten subcomatus, *Münst.*
Lima punctata, *Phil.*
—— Pontonis, *Lyc.*
—— pectiniformis, *Schloth.*
Myoconcha striatula, *Goldf.*
—— elongata, *Mor. & Lyc.*
Perna quadrata, *Sow.*
Trichites nodosus, *Lyc.*
Pteroperna costatula, *Deslong.*
—— gibbosa, *Lyc.*
—— lata, *Phil.*
Gervillia lanceolata, *Goldf.*
—— aurita, *Lyc.*
—— tortuosa, *Phil.*
Arca cancellata, *Phil.*
—— carinata, *Koch & Dunk.*
—— Prattii, *Mor. & Lyc.*
Cucullæa cucullata, *Goldf.*
Macrodon Hirsonensis, *d'Arch.*
Pinna cuneata, *Phil.*
—— hastata, *Lyc.*
Unicardium gibbosum, *Lyc.*
Opis Moreausus, *Buvign.*
—— gibbosus, *Lyc.*
—— elongatus, *Lyc.*
Trigonia costata (var. pullus), *Sow.*
—— costatula, *Lyc.*
—— angulata, *Sow.*
—— striata, *Sow.*
—— subglobosa, *Mor. & Lyc.*
Cypricardia cordiformis, *Desh.*
Cyprina curvirostra, *Lyc.*
—— nuciformis, *Lyc.*
—— Suevica, *Goldf.*

Cyprina picta, *Lyc.*
Lucina Orbigniana, *d'Arch.*
Astarte depressa, *Goldf.*
—— bullata, *Lyc.*
—— transversa, *Lyc.*
—— excavata (var. compressiuscula), *Sow.*
Myopsis punctata, *Buck.*
—— compressus, *Lyc.*
Goniomya angulifera, *Sow.*
Anatina pinguis, ? *Agass.*
Ceromya concentrica, *Sow.*

Terebratula submaxillata, *David.*
—— fimbria, *Sow.*
—— carinata, *Lam.*
—— galeiformis, *David.*
—— plicata, *Buck.*
—— simplex, *Buck.*

Rhynchonella subobsoleta, *David.*
—— concinna, *Sow.*
—— subtetrahedra, *David.*
—— Lycetti, *David.*

Pedina Bakeri, *Wright.*
Stomechinus germinans, *Phil.*
Polycyphus Deslongchampsi, *Wright.*
Pseudodiadema depressum, *Agass.*

Cladophyllia, sp.
Cosmoseris vermicularis, *M'Coy.*
Convexastræa Waltoni, *Edw. & Haime.*
Isastræa limitata, *Lamx.*
—— Davidsoni, *Edw. & Haime.*
Thamnastræa Defranciana, *Michl.*
—— concinna, *Goldf.*
—— Mettensis, *Edw. & Haime.*
Stylina solida, *M'Coy.*

Many of the *Gasteropoda*, and most of the *Conchifera*, in the above were collected by my friend Mr. Lycett, chiefly from the marl near Nailsworth; the *Brachiopoda* and *Echinodermata* I collected at Hartley Bottom, near the Seven Springs; the Corals were collected near Cheltenham by myself, and near Sheepscombe and Birdlip by my friend Mr. J. Jones. To Mr. Lycett we are indebted for cataloguing most of the species of *Mollusca*.

B. Section VI.—At the Peak near Robin Hood's Bay, Yorkshire Coast.

a. The Zones of Ammonites Murchisonæ *and* A. Humphriesianus.

The middle and lower subdivisions of the Inferior Oolite, together with the zone of *Ammonites Jurensis*, are admirably exposed in the magnificent coast-section at the Peak near Robin Hood's Bay.

No. 1. On descending from the top of the cliff about half a mile south of Peak Hall, we first pass over some beds of the upper sandstones; they are of a slaty structure, and are much shivered. Beneath these—

No. 2. The Grey Limestone ("Bath Oolite" of Phillips) forms two conspicuous bands in the cliff, separated from each other by softer shaly beds. This rock is very hard and persistent; and the shales above and below it having been decomposed, it stands out in relief. The oolite may be from fifteen to twenty feet thick, and is fossiliferous.

No. 3. The Block Sand-rock crops out beneath the grey limestone. It is in part a thick-bedded sandstone, which forms a very prominent band in the cliff. The lower part of this bed becomes slaty where it rests upon the Millepore-rock.

No. 4. The Millepore-bed is a hard crystalline calcareo-siliceous rock, partly oolitic, abounding with fragments of Crinoids, Echinoderms, Polyzoans, and shelly fragments.

No. 5. The Millepore-rock rests upon a bed of thick sandstone,

which forms an immense prominence at the base of the cliff. In consequence of the disintegration of the shaly bed beneath the block-sandstone, there has been a considerable fall from the upper beds, and an extensive waste in that portion of the cliff. In fact, a wide amphitheatre is here excavated, the floor of the terrace being formed by the crystalline Millepore-rock, upon which large blocks of grey limestone and block-sandstone have fallen, looking like glacial boulders on a raised beach. From these detached masses of grey limestone a good series of oolitic fossils may be obtained. On descending from this thick sandstone bluff, we meet with the upper sandstones of the "Dogger," which, near this point, rise on the shore.

b. The Dogger.

No. 1. The "Dogger" rises on the shore to the south of Blue Wick, where it has a considerable thickness; but it becomes gradually thinner as it rises in the cliff. The uppermost bed is a strong sandstone, of a reddish colour; it is extremely hard, and contains much iron, and has a number of small rounded pebbles disseminated through the bed, which are sometimes in seams. Where the rock is weathered, they project in relief from the surface, and are well seen from the shore. This sand-rock appears to be unfossiliferous. It measures about eight feet in thickness. It rests upon, or rather it encloses, a fossiliferous seam, containing all the characteristic fossils of the Dogger, the following list of which is made from specimens contained in Mr. Leckenby's cabinet.

Fossils of the Dogger, in Mr. Leckenby's Cabinet.

Natica adducta, *Phil.*
—— cincta, *Phil.* sp.
—— tumidula, *Phil.*
Chemnitzia vetusta, *Phil.* sp.
—— Scarburgensis, *Lyc. & Mor.*
Cerithium multipunctatum, *Deslong.*
—— Beanii, *Lyc. & Mor.*
——, sp. nov.
Nerinæa cingenda, *Sow.* not *Phil.*
—— cingenda, *Phil.* not *Sow.*
Alaria Phillipsii, *Lyc. & Mor.*
Turritella quadrivittata, *Phil.*
Littorina punctura, *Bean.*
Trochus bisertus, *Phil.*
—— pyramidatus, *Phil.*
—— jugosus, *Bean, MS.*
Delphinula granata, *Bean, MS.*
Turbo elaboratus, *Lyc. & Mor.*
—— Phillipsii, *Lyc. & Mor.*
—— funiculatus, *Phil.*
Nerita lævigata, *Sow.* not *Phil.*
—— lævigata, *Phil.* not *Sow.*
—— bellulata, *Bean, MS.* (Approaches *lævigata*, Sowerby, but is more conical and has a channeled suture.)
Trochotoma calyx, *Phil.* sp.
——, sp. n.

Actæonina humeralis, *Phil.* sp.
—— Sedgvicii, *Phil.* sp.

Rhynchonella obsoleta, *Sow.* sp.
Ostrea solitaria, *Sow.*
—— speciosa, *Bean, MS.*
Pecten arcuatus, *Sow.*
Hinnites abjectus, *Phil.* sp.
Lima, sp. n.
Avicula Muensteri, *Goldf.*
Gervillia tortuosa, *Phil.* sp.
—— Hartmanni, *Goldf.*
Pteroperna plana, *Lyc. & Mor.*
—— striata, *Bean, MS.*
Modiola aspera, *Sow.*
—— plicata, *Sow.*
—— imbricata, *Sow.*
—— cuneata, *Sow.*
Mytilus cuneatus, *Phil.*
Cucullæa cancellata, *Phil.*
—— reticulata, *Phil.*
Macrodon Hirsonensis, *d'Arch.* sp.
Nucula variabilis, *Sow.*
Leda lacryma, *Sow.* sp.
Cardium acutangulum, *Phil.*
—— gibberulum, *Phil.*
—— striatulum, *Sow.*
—— incertum, *Phil.*

Cardium crenulatum, *Bean, MS.*
Trigonia costata *, *var.* pullus, *Sow.*
—— V-costata, *Lyc.*
—— composita, *Lyc.*
Opis Phillipsii, *Morris.*
Astarte elegans, *Sow.*
—— excavata, *Sow.*
—— minima, *Phil.*
Isocardia cordata, *Buckm.*
Cytheræa dolabra, *Phil.*
—— plana, *Bean, MS.*
Quenstedtia lævigata, *Phil.* sp.
——? tenuissima, *Bean, MS.*
Tancredia axiniformis, *Phil.* sp.
Mya? æquata, *Phil.*
Corbula dubiosa, *Bean.*
Thracia, sp. nov.
Goniomya angulifera, *Sow.* sp.
Ceromya Bajociana, *d'Orb.*
Gresslya abducta, *Phil.* sp.
Sowerbya triangularis, *Phil.* sp.

No. 2. This very richly fossiliferous seam is made up of a congeries of shells, which lie in all directions in the bed. *Chemnitzia* and *Nerinæa* are found above; and *Natica*, *Astarte*, and *Trigonia* are in great abundance beneath. The matrix is deeply impregnated with ferruginous matter. The shelly conglomerate is extremely hard, of a deep-brown colour, and forms a conspicuous band, about one foot in thickness, in the cliff. It rests upon a second unfossiliferous sand-rock, similar to the upper sandstone, the fossiliferous seam being interstratified between them.

No. 3. Beneath the preceding is another sandstone, charged with iron, but with few or no fossils, and measuring from six to eight feet in thickness. The three beds may be considered as one ferruginous sandy deposit, with an intermediate fossiliferous zone. The whole measures from 16 to 18 feet.

* [This valuable note has been contributed by John Lycett, Esq.] *Trigonia composita*, Lyc. (Syn. *Trigonia striata*, Phillips, Geol. of Yorksh. vol. i. pl. 11. fig. 38., not *T. striata*, Sow.). This new designation is proposed for the Dogger ally of *T. striata*, figured and catalogued by Phillips, and subsequently quoted by Williamson and other palæontologists. D'Orbigny, in his 'Prodrome,' judging probably solely from the figure given by Phillips, refers it to the *T. tuberculata*, Agassiz, a species which, in Würtemberg, appears to occupy nearly the same geological position; but an examination of the Yorkshire specimens renders it impossible to acquiesce in this view. Many of the *Testacea* at Blue Wick have suffered compression; and their general condition in other respects is not satisfactory; to these obstacles to a clear comprehension of them, it must be added that the *Trigonia* itself is very variable in the characters of its costæ, which may be described as tuberculated rather than crenulated. Owing to these varying conditions, it happens that the greater number of the specimens differ somewhat from the little figure given by Professor Phillips, although it is not unlikely that the figure in question may fairly represent some particular specimen. *Trigonia composita* is more elongated than *T. striata*, but less so than *T. tuberculata*; the umbones are elevated and moderately recurved; the marginal and inner carinæ, which are conspicuous and tuberculated, have a graceful curvature; the area is moderately large, flattened, with dense and delicate transverse striations, bounded by the two tuberculated carinæ, and traversed by a mesial oblique row of tubercles; the lanceolate space is lengthened and smooth. It rarely happens that the costæ have the regular curvature which is seen in *T. striata* or in *T. formosa*; they often form a kind of undulation toward the posterior side: the costæ are then more oblique, and little prominent toward the anterior side, they approach the carina at a less angle than in the before-mentioned species, and likewise differ from them in having the largest tubercles near to the carinal extremity. The most striking distinction consists in the three rows of tubercles upon the area, and its bounding carinæ,—a feature which rather tends to connect it with the considerable group of species allied to *Trigonia clavellata*. In the Dogger, at Blue Wick, it is tolerably abundant.—J. L.

No. 4. Another ferruginous sand-rock appears below the latter, which contains seams with fossil shells. In these I observed *Trigonia*, *Astarte*, and *Nerinæa*. It measures about 5 feet, and is underlain by

No. 5. A yellowish sandstone, in which I found seams of small rounded pebbles, lying at the bottom of the bed. The pebbly conglomerates are about four inches in thickness, and occur at intervals. I observed in the upper part some fragments of *Belemnites*, a *Cerithium*, and a small shell resembling an *Avicula*. The bed measures about 5 feet in thickness, and appears to be the lowest of the Inferior Oolite. Those which follow between No. 5 and the Alum-shale, I refer to the zone of *Ammonites Jurensis**.

2. The Zone of Ammonites Humphriesianus.

Synonyms.—"Inferior Oolite of Dundry Hill," Conybeare and Phillips, 1822, 'Outlines,' p. 236; "Grey limestone, Bath or Great Oolite," Phillips, 'Geol. of York.' 1829, p. 149; "Zone of *Ammonites Humphriesianus*," Wright, 'Monogr. on Brit. Ool. Echinoderms,' 1856.

Foreign Equivalents.—"Eisenrogenstein (part) und Walk-Erde Gruppe," Fromherz, 1838, 'Die Juraformation des Breisgaues,' pp. 13–17; "Brauner Jura γ und δ," Quenstedt, 1843, 'Flözgeb.' p. 538; "Calcaire ferrugineux," Terquem, 1855, 'Paléontol. du Départ. de la Moselle,' p. 25; "Blane Kalke, Korallenschicht, Giganteus-Thone, und Ostreen-Kalk" (Quenstedt), Pfizenmayer, 'Zeitsch. Deut. geol. Gesellsch.' 1853, vol. v. tab. 16. (Oppel, p. 333.)

Description.—The zone of *Ammonites Humphriesianus* forms an important subdivision of the Inferior Oolite, and is characterized by a fauna very rich in many species of *Gasteropoda* and *Cephalopoda*, which are found in no other zone of life.

The lithological composition of the fossiliferous beds, whether examined in France, England, or Germany, is very uniform throughout. Everywhere the calcareous matrix is freely strewed with small oviform ferruginous particles, which impart an iron-shot character to the rock,—a physical feature so well exemplified in the oolites of Dundry and Yeovil, in England, and of Bayeux and Moutiers, in France.

The best types of this zone in England are the lower portion of the Oolites in the section at Dundry Hill near Bristol, and the sections seen in the extensive quarries near Yeovil and Sherborne, Somerset, and Burton-Bradstock and Chideock, Dorset. The peculiar lithological character of some of the beds of this subdivision, containing, as they do, ferruginous oolitic grains disseminated in a brown mudstone, led my lamented friend the late H. E. Strickland, Esq., to consider the iron-shot oolite of Dundry as the equivalent of

* It is dangerous to attempt this coast-section without a guide; and I would advise geologists desirous of examining the locality to obtain the services of Mr. Peter Cullen, of Scarborough, who possesses a most accurate knowledge of all the beds here exposed. Without his able assistance, I feel that my task would have been indifferently performed.

the Cephalopoda-bed of Haresfield Hill. On this subject he observed—"A few miles to the south the Pisolite disappears, and is replaced near Painswick and at Haresfield Hill by strata containing ferruginous oolite-grains in a brown paste. This is the precise equivalent of the well-known oolite of Dundry, near Bristol, which may be recognized as far as Bridport, on the Dorset coast*." A comparison, however, of the species of *Ammonites* and other shells collected in these different localities shows that, besides a similarity in lithological structure, there is nothing in common between the strata.

The position of the Ammonite-bed at Dundry Hill has likewise been a source of error, placed, as it is, so near to the Upper Lias sands, and overlain by other shelly beds and thick-bedded oolitic limestones, just as the Cephalopoda-bed at Frocester Hill and Haresfield Hill is overlain by the shelly beds and oolitic limestones of the zone of *Ammonites Murchisonæ*. The fact, however, appears to have been overlooked, that the Oolitic beds in the South of England vary much in thickness in different localities, and even thin out within short distances from each other. When this happens, strata which in one locality are separated by a considerable thickness of rock, in others are brought into juxtaposition. The thinning out of the zone of *Ammonites Murchisonæ* and the absence of the zone of *Ammonites Humphriesianus*, near Burford and other localities in the north-east parts of the Northleach district, have brought the zone of *Ammonites Parkinsoni* in close relation with the clays of the Upper Lias; so, in like manner, the thinning out of the zone of *Ammonites Murchisonæ* at Dundry Hill has brought the zone of *Ammonites Humphriesianus* in close relation with the sands of the Upper Lias.

In the Northern Cotteswolds the zone of *Ammonites Humphriesianus* is best represented by a series of ferruginous oolitic limestones, raised for road-material at Cleeve Hill, between Cheltenham and Winchcomb, and which are well exposed in the following section.

A. Section VII.—The Rolling-bank Quarry; Cleeve Hill, North End.

On leaving the Winchcomb road, about a quarter of a mile beyond the "Rising Sun," by the new stables, and ascending the escarpment at this point, the Pea-grit is seen in position near the wall, containing *Terebratula simplex*, *Pygaster semisulcatus*, numerous fragments of *Pentacrinites*, and other fossils of this rock. A few yards above, the freestone (much displaced) crops out southward; and still higher up the hill we enter the quarry called by the workmen the "Rolling-bank." In the 44th sheet of the Geological Survey Maps, this escarpment is marked "Tumbled Oolite and Under-cliffs,"—names which signify the disturbed condition of some of the beds, produced probably by a slip of the Oolitic strata over the unctuous clay of the Upper Lias.

* Quart. Journ. Geol. Soc. vol. vi. p. 250 (1850).

The lower Trigonia-grit, which is seen in position on the plateau above, has rolled over and formed the glacis of the hill; it has thereby covered the beds of the *A. Humphriesianus* zone, which here immediately underlie this grit. Recent workings having more fully exposed the *A. Humphriesianus* bed than formerly, I have collected therefrom a series of about forty species of fossils characteristic of the zone, and have likewise ascertained the stratigraphical sequence of the beds composing this middle subdivision in the Northern Cotteswolds.

The Rolling-bank Quarry is capped by about 18 inches of the lower Trigonia-grit, consisting of loose, incoherent fragments of a light-coloured oolitic limestone, beneath which are exposed the uppermost beds of

The Ammonites Humphriesianus *Zone.*

No. 1. *The Terebratula Phillipsii Bed* is a light buff-coloured compact earthy limestone; many of the blocks are almost entirely composed of the shells of *Brachiopoda*, of which that of *Terebratula Phillipsii* greatly predominates. The bed measures from 2 to 4 feet in thickness, and contains

Lima proboscidea, *Sow.*
Terebratula Phillipsii, *Mor.*
—— perovalis, *Sow.*
—— carinata, *Lamk.*
Terebratula Buckmani, *Davids.*
Rhynchonella spinosa, *Schloth.*
—— subtetrahedra, *Davids.*
—— angulata, *Sow.*

No. 2. *The Road-stone* consists of a coarse, brown, ferruginous, oolitic limestone, extremely hard and crystalline, traversed in some parts by sandy layers, and containing in others calcareo-siliceous concretions, which have a crystalline structure and unequal fracture. It forms a durable road-material, and is raised for that purpose.

It varies from 10 to 15 feet in thickness, and contains a small assemblage of *Mollusca*, which are nearly all in the state of moulds. The upper portion of the road-stone contains a sandy stratum, in which a remarkable Gasteropod, nearly identical with *Melania* (*Chemnitzia*) *striata*, Sow., from the Coralline Oolite, occurs in considerable numbers. This shell has been separated from the Coral Rag species by Dr. Oppel, and named *Chemnitzia Sæmanni*. This is the only bed and locality from which I know it in the Cotteswolds; it is found, however, in the grey limestone at Scarborough, the correlative of this zone. The lower portion of the Road-stone contains most of the species of the subjoined list. *Trichites undulatus*, Lyc., is found very large, and sometimes well preserved in the rock, but cannot be extracted entire. *Pholadomya Heraulti*, Ag., likewise attains gigantic dimensions.

Ammonites Orbignianus, *Wr.* (Brongniarti, *d'Orb.*)
—— Humphriesianus, *Sow.*
—— Brocchi, *Sow.*
—— Braikenridgii, *Sow.*

Chemnitzia Sæmanni, *Oppel.*
—— lineata, *Sow.*
Pleurotomaria fasciata, *Sow.*
—— elongata, *Sow.*
—— constricta, *Deslong.*
Turbo lævigatus, *Sow.*

Ostrea flabelloides, *Lamk.*
——, large flat species.
Hinnites tuberculosus, *Goldf.*

Lima proboscidea, *Sow.*
—— Etheridgii, *Wr.*
—— duplicata, *Sow.*
Trichites undulatus, *Lyc.*
Astarte excavata, *Sow.*
Cyprina (a mould).
Cypricardia cordiformis, *Desh.*
Myacites calceiformis, *Sow.*
Gervillia consobrina, *d'Orb.*
Mytilus explanatus, *Mor.*
Pholadomya Heraulti, *Ag.*
Homomya crassiuscula, *Lyc.*
Myoconcha crassa, *Sow.*
Pteroperna plana, *Lyc.*
Trigonia costata, *Sow.*
—— striata, *Sow.*
—— decorata, *Ag.*
Modiola imbricata, *Sow.*
Pinna fissa, *Phil.*

Rhynchonella subtetrahedra, *Davids.*

No. 3. *The Oyster-bed* consists of a coarse, brown, ferruginous, sandy marl, with inconstant layers of ragstone. The fossils lie chiefly in the sand. The bed is about one yard in thickness, and contains—

Ostrea flabelloides, *Lamk.* (and three other varieties of this Oyster).
Ostrea pyxiformis, *Wr.*, sp. nov.
Pecten demissus, *Goldf.*
Lima proboscidea, *Sow.*
—— Etheridgii, *Wr.*
Monotis tenuicostata, *Wr.*, sp. n.
Gresslya abducta, *Phil.*
Pleuromya tenuistriata, *Ag.*
Pholadomya Heraulti, *Ag.*
—— ovulum, *Ag.*
—— media, *Ag.*
—— Devalquei, *Lyc.*

Serpula grandis, *Goldf.*
—— limax, *Goldf.*

Clypeus Michelini, *Wr.*
Stomechinus germinans, *Phil.*
Pseudodiadema depressum, *Ag.*

No. 4. *The Marl-bed.*—Beneath a thin band of clay which underlies the oyster-bed, and forms the floor of the quarry, a bed of soft mudstone is exposed at one or two points. It contains many fossils, with their shells; but the tests were in such a rotten state, that few species could be determined. From the position of the bed and its organic contents, it appears to be the upper portion of the oolite-marl, as this rock is in position and well developed within 200 yards of the "rolling-bank." I noted the following species in the portions which I examined:—

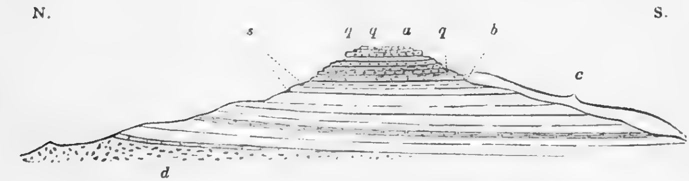
Chemnitzia, sp.
Nerinæa, sp.
Modiola plicata, *Sow.*
Pecten lens, *Sow.*
Cypricardia cordiformis, *Desh.*
Terebratula Etheridgii, *Davids.*
Montlivaltia, sp.

B. *Dundry Hill.*—Dundry Hill has been long known to collectors as a rich locality for fossils; but the true relations of its beds of Inferior Oolite with those of other regions have not until now been accurately described. Having studied the interesting sections of this locality in former years, in conjunction with my friend Mr. Etheridge, and knowing how carefully he had examined the several beds at Dundry for the purpose of determining the true horizon of the different species of fossils from this locality, which are contained in the fine Dundry collection in the Bristol Institution, I asked my friend to contribute to this memoir his notes and sections. And this he has most kindly done, adding thereto a full list of the species contained in the different beds. This important communication will be found to form one of the most valuable portions of this memoir; and for it I beg to return my best thanks.

Notes on Dundry Hill. By R. ETHERIDGE, Esq., F.G.S.

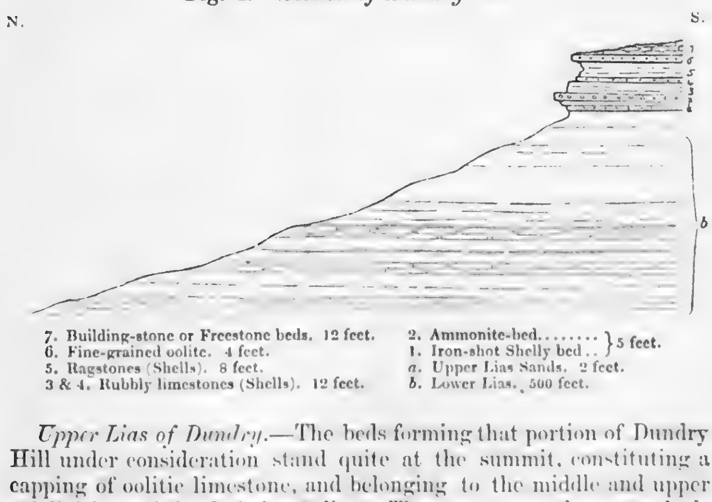
Dundry Hill, which rises to an elevation of 700 feet above the level of the sea, is the most extreme westerly outlier of the Oolitic hills, and is removed nine miles from that range. The smaller outlying hills of Wilmington, Stantonbury, and Winsbury, to the east, naturally connect Dundry with the main body of the Oolitic Range, well exemplified at English Coomb, English Batch, and Camerton; also with the same extensive series at Doulting, Batcombe, Burton, and Castle Carey, south of the Mendips, where the beds much resemble those of Dundry; and throughout the Yeovil district generally these strata, both lithologically and palæontologically, are still more like those of Dundry.

Fig. 3.—*Section across Dundry Hill, showing its Capping of Inferior Oolite.*



a. Inferior Oolite.
b. Position of the Upper Lias.
c. Lower Lias.
d. New Red Sandstone.
q, q, q. Quarries.
s. Springs.

Fig. 4.—*Section of Dundry Hill.*



7. Building-stone or Freestone beds. 12 feet.
6. Fine-grained oolite. 4 feet.
5. Ragstones (Shells). 8 feet.
3 & 4. Rubbly limestones (Shells). 12 feet.
2. Ammonite-bed........ } 5 feet.
1. Iron-shot Shelly bed.. }
a. Upper Lias Sands. 2 feet.
b. Lower Lias. 500 feet.

Upper Lias of Dundry.—The beds forming that portion of Dundry Hill under consideration stand quite at the summit, constituting a capping of oolitic limestone, and belonging to the middle and upper subdivisions of the Inferior Oolite. They rest upon the upper beds of the Upper Lias, which are feebly represented here, their only

evidence being the few fossils enumerated below, which are widely scattered through the beds.

Belemnites tripartitus, *Schloth.*
Ammonites bifrons, *Brug.*
—— communis, *Sow.*
Pholadomya, sp.
Modiola, sp.

These are, as far as I know, all the species here found in the Upper Lias below the sands. They are likewise much dwarfed.

Lower Lias of Dundry.—Few districts exhibit a finer sequence of the Lower Lias shales and limestones than the immediate neighbourhood of Bristol; it is my intention, however, only to mention these beds at Dundry Hill in their relation to those of the Inferior Oolite which overlie or cap them.

The lowest members of the Lias in the Dundry district are well exhibited at Bedminster Down, Keynsham, Whitchurch, Queen Charlton, Norton Malreward, Winford, and Barrow; and ascending from all these points at the foot of the hill, to the summit, we pass over the higher beds of the Lower Lias, which consist, as usual, of alternating limestones and shales, under various conditions. The total thickness of the Lias, constituting the main body of the hill, from its junction with the Red Marl at Bedminster Down to its junction with the overlying Inferior Oolite at the summit of the hill, is about 550 feet; but in this fine developement there are *no traces whatever of the Middle Lias or Marlstone* as exhibited in the Bath district and in the Cotteswold Range generally. We can only infer that some portion of the true Upper Lias has been deposited here,—the only evidence being the few characteristic fossils before mentioned.

Upper Lias Sands of Dundry.—All the evidence afforded of this series is a bed, 2 or 3 feet in thickness, immediately below the true Oolites. In these sands, at the western end of the hill, we find dwarfed specimens of

Modiola plicata, *Sow.*
Pholadomya fidicula, *Sow.*
—— arenacea, *Lyc.*
Lima bellula?, *Lyc.* var.
Belemnites irregularis, *Schloth.*
—— compressus, *Voltz.*

I am not aware that these sands are thicker in any other part of the hill; they pass downwards into the shales and clays of the Lias beneath.

Inferior Oolite of Dundry.—*No.* 1. *Mollusca-bed, or Shelly bed.* Immediately upon the zone of the semi-indurated sands, with its few fossils, rests the lowest member here of the Inferior Oolite (marked No. 1 in the section fig. 4). This mollusca-bed, between 2 and 3 feet in thickness, is extremely rich in the type-forms of life of the period, and is composed of coarse, brown, ferruginous or iron-shot oolitic grains. This stratum passes insensibly (lithologically) into a higher zone or bed (No. 2), which contains the well-known *Cephalopoda* of Dundry Hill. These two beds are so intimately connected, that it is difficult to draw any line of demarcation between them,—the main feature observable being the large preponderance of *Gasteropoda* and *Conchifera*, which occupy *the lower portion* resting upon the sands, whereas the upper or Cephalopod division (No. 2) is entirely or mainly composed of *Ammonites* and *Nautili.*

I have determined the following fossils from this mollusca-bed (lower shelly bed), specimens of most of which are in my own cabinet, and in the fine collection in the Museum of the Bristol Philosophical Institution, and likewise in that of Dr. Wright.

Fossils of No. 1. Iron-shot Shelly Bed.

Cirrus Leachii, *Sow.*
—— nodosus, *Sow.*
Littorina ornata, *Sow.*
——, sp. nov.
Nerinæa Anglica, *d'Orb.*
Pleurotomaria armata, *Sow.*
—— abbreviata, *Sow.*
—— elongata, *Sow.*
—— fasciata, *Sow.*
—— ornata, *Sow.*
—— punctata, *Sow.*
—— sulcata, *Sow.*
Trochus, sp.
Monodonta lævigata, *Sow.*
Alaria Phillipsi, *Lyc.*
Chemnitzia lineata, *Sow.*

Pecten lens, *Sow.*
—— barbatus, *Sow.*
Arca elongata, *Pratt.*
Macrodon Hirsonensis, *d'Archiac.*
Cucullæa oblonga, *Sow.*
—— cucullata, *Goldf.*
Astarte elegans, *Sow.*
Astarte obliqua, *Desh.*
—— subtrigona, *Münst.*
—— orbicularis, *Sow.*
—— excavata, *Sow.*
Homomya crassiuscula, *Lyc.*
Ostrea flabelloides, *Lamk.*
Mytilus, sp.
Pleuromya donacina, *Ag.*
—— tenuistriata, *Ag.*
—— elongata, *Ag.*
Myopsis Jurassi, *Brong.* sp.
Opis trigonalis, *Sow.*
—— lunulatus, *Sow.*
Pholadomya fidicula, *Sow.*
—— ovulum, *Ag.*
—— Heraulti, *Ag.*
Tancredia donaciformis, *Lyc.*
Lucina, sp.
Unicardium gibbosum, *Lyc.*
Sphæra Madridii, *d'Arch.*
Modiola Sowerbyii, *d'Orb.* (plicata, *Sow.*).
Hinnites tuberculosus, *Goldf.*

Ammonite-bed (*No.* 2).—The chief feature observable in this remarkable stratum is the persistency of certain species of *Ammonites*, most of which do not pass upwards into the higher strata. Lithologically, this and the underlying shelly bed closely resemble each other. This bed measures about 3 feet; but it is irregular, varying from 2 to 3 feet in thickness. The following list has been obtained from this Ammonite-zone:—

Fossils of No. 2. Ammonite-bed.

Ammonites Blagdeni, *Sow.*
—— Braikenridgii, *Sow.*
—— Brocchii, *Sow.*
—— dimorphus, *d'Orb.*
—— Humphriesianus, *Sow.*
—— læviusculus, *Sow.*
—— Sowerbyi, *Mill.*
—— Dundriensis, *Worsley.*
—— Brongniarti, *Sow.* (non *d'Orb.*).
—— Orbignianus, *Wr.* (Brongniarti, *d'Orb.*).
—— Eudesianus, *d'Orb.*
—— concavus, *Sow.*
Nautilus excavatus, *Sow.*
—— lineatus, *Sow.*
Belemnites canaliculatus, *Schloth.*
Belemnites ellipticus, *Mill.*
—— sulcatus, *Mill.*

Monodonta lævigata, *Sow.*
Littorina ornata, *Sow.*
Nerinæa Anglica, *d'Orb.*
Turbo Milleri, *Wr.*, n. sp.
Pleurotomaria elongata, *Sow.*
—— punctata, *Sow.*
Lima pectiniformis, *Schloth.*
Pecten lens, *Sow.*
Modiola Sowerbyii, *d'Orb.* (plicata, *Sow.*).
Arca cancellata, *Phil.*
Opis trigonalis, *Sow.*
—— similis, *Desh.*
Terebratula Etheridgii, *Davids.*

Conchifera-beds (*Nos.* 3 *and* 4).—Succeeding these ferruginous or iron-shot beds, we have a succession of irregular semi-oolitic deposits,

or a stratified rubbly limestone-rock, conspicuous for the number of species of *Conchifera* therein contained (chiefly *C. Dimyaria*). It measures about 8 feet in thickness, and passes upwards into a hard, smooth, fine-grained limestone, 4 or 5 feet thick (No. 4), containing numerous *Brachiopoda*. The following species I have obtained and determined from this shelly series. They are catalogued together; but the majority are obtained from the lower bed (the rubbly and more oolitic portion of the two; No. 3).

Fossils of Nos. 3 *and* 4. *Conchifera-beds.*

Ammonites Sowerbii, *Mill.*	Ceromya Bajociana, *d'Orb.*
—— Humphriesianus, *Sow.*	—— concentrica, *Sow.*
——, sp. nov.	Myoconcha crassa, *Sow.*
—— Truellei (*var.* compressus), *d'Orb.*	Trigonia striata, *Sow.*
—— læviusculus, *Sow.*	—— costata, *Sow.*
——, sp. nov.	Pecten lens, *Sow.*
Nautilus excavatus, *Sow.*	—— barbatus, *Sow.*
Belemnites sulcatus, *Mill.*	Ostræa flabelloides, *Lamk.*
Pleurotomaria elongata, *Sow.*	Mytilus cuneatus, *Phil.*
—— punctata, *Sow.*	Gervillia pernoides, *Deslong.*
Littorina (moulds).	Pinna cuneata, *Phil.*
Natica (moulds).	Arca, sp.
Myopsis Jurassi, *Brong.*	Unicardium depressum, *Phil.*
Pleuromya donacina, *Ag.*	Trichites nodosus, *Lyc.*
Pholadomya fidicula, *Sow.*	Rhynchonella globata, *Sow.*
—— obtusa, *Sow.*	—— spinosa, *Schloth.*
—— media, *Ag.*	—— subtetrahedra, *Dav.*
—— Heraulti, *Ag.*	Terebratula globata, *Sow.*
Lima duplicata, *Sow.*	—— perovalis, *Sow.*
—— Etheridgii, *Wright*, sp. nov.	—— sphæroidalis, *Sow.*
—— gibbosa, *Sow.*	—— Phillipsii, *Morris.*
—— punctata, *Phil.* ?	Stomechinus germinans, *Phil.*
—— pectiniformis, *Schloth.*	Pseudodiadema depressum, *Ag.*
Modiola gibbosa, *Sow.*	Hemicidaris granulosa, *Wright.*
—— plicata, *Sow.*	Hemipedina Bakeri, *Wright.*
Astarte excavata, *Sow.*	Thamnastræa fungiformis, *Edw. & Haime.*
—— elegans, *Sow.*	
—— obliqua, *d'Orb.*	Latomæandra Flemingii, *Edw.&Haime.*

The Ragstones of Dundry, forming the Zone of Ammonites Parkinsoni.—*Ragstone-beds* (*No.* 5).—The smooth hard limestones just mentioned are succeeded by loose and semi-oolitic beds, about 8 feet in thickness. These are, or were, exposed in quarries both on the north and south sides of the hill,—one to the west of the church, but at a lower level; the other on the south side, and on the road to Chew Magna. The fossils are cemented together by a marly paste, which decomposes under change of atmosphere.

The organic remains in these beds somewhat agree with those of No. 3; but they are not so numerous either in species or individuals, and are nearly all in the form of casts. Several undescribed *Ammonites* occur in these beds*. The following is the list of species which I have obtained from this series; but I believe that it is far from complete.

* Many of these were named in MS. notes by Mr. S. Worsley some years ago, when the beds were extensively worked for lime and for road-purposes. These fossils are still in the Museum of the Bristol Institution, with Mr. W.'s names attached.

Fossils from No. 5. The Ragstones.

Ammonites Parkinsoni, *Sow.* (small).
—— Humphriesianus, *Sow.*
—— læviusculus, *Sow.*
——, sp. (unnamed; in form of moulds).
Belemnites ellipticus, *Mill.*
Peurotomaria proteus, *Deslong.*
—— elongata, *Sow.*
Littorina (in moulds).
Myopsis Jurassi, *Brong.*
Pleuromya elongata, *Roemer.*
—— donacina, *Ag.*
Pholadomya ovulum, *Ag.*
—— obtusa, *Sow.*
—— fidicula, *Sow.*
—— Heraulti, *Ag.*
Lima pectiniformis, *Schloth.*
Modiola gibbosa, *Sow.*
Astarte excavata, *Sow.*
Ceromya Bajociana, *d'Orb.*
Trigonia striata, *Sow.*
Tancredia donaciformis, *Lyc.*
Gervillia Hartmanni, *Goldf.*
Pecten lens, *Sow.*
Terebratula perovalis, *Sow.*
—— sphæroidalis, *Sow.*
—— globata, *Sow.*
Rhynchonella plicatella, *Sow.*
—— spinosa, *Schloth.*
Magnotia Forbesii, *Wright.*
Stomechinus intermedius, *Ag.*
Echinobrissus clunicularis, *Lhwyd.*
Holectypus depressus, *Lamk.*
Isastræa helianthella, *M'Coy.*
Stylina solida, *M'Coy.*

Fine-grained Oolite or Building-stone (*No.* 6).—This undoubtedly overlies the Ragstones, and can only be seen on Dundry Down, in the old open and under-ground quarries, where it has been extensively worked for church-building and other purposes.

This fine-grained oolite much resembles the Portland-stone. Few or no organic remains occur in this bed, which measures from 4 to 5 feet in thickness.

Coarse Oolite. Building-stone or Freestone Beds (*No.* 7).—This is the highest set of beds observable on Dundry Hill; and although they are not rich in fossils, still there are certain conditions of the beds and forms of fossils deserving special notice. Most, if not all, of the building-stone of Dundry comes from quarries opened in this "top rock" (so called by the men). Numerous casts of *Trigoniæ*, and several species of Corals, are common to this and the upper part of the beds 3 and 4; whilst other fossils are rare. The mass of the rock is composed of finely triturated shell-sand, or débris of shells closely and densely arranged, which, on weathering, stand out in sharp relief.

False-bedding constantly occurs throughout this series. The organic contents of this building-stone, as far as I have been able to determine, are as follows:—

Fossils of No. 7. Building-stone or Freestone.

Trigonia costata, *Sow.* } Only sparingly
—— striata, *Sow.* } distributed.
Isastræa explanata, *Goldf.*
—— helianthella, *M'Coy.*
Stylina solida, *M'Coy.*
Thamnastræa Defranciana, *Edw. & Haime.*
Latomæandra Flemingii, *Edw. & Haime.*
Isastræa tenuistriata, *M'Coy.*
Pentacrinus Milleri, *Austin.*

—R. E.

C. *Section from the Cornbrash to the Millepore-bed, in Gristhorpe Bay, Yorkshire**.—No. 1, the Cornbrash, rises on the scar at Newbiggin Wyke, at the south side of Gristhorpe Bay, near the place

* The reader may consult with much profit Professor Williamson's excellent notes on this section in the Trans. Geol. Soc. 2nd series, vol. vi. p. 143. More

where the Kelloway Rock first appears on the shore. At Puddinghole it is seen in the cliff, and may be traced along the coast-section as far as Gristhorpe Sands; from thence to Redcliff it is covered by Drift; at Redcliff it is thrown down by a fault, and is seen there at low water on the shore. At the northern extremity of Cayton Bay it rises again; but the fault at Ewe Nab has brought it down to the shore, where a small portion only is visible at half-ebb. At the north side of the Castle Hill it is raised in the cliff by the dislocation which has disturbed the beds in that locality; and it finally sinks and disappears near Peasholm Beck. The Cornbrash is separated from the Kelloway Rock by a bed of dark-bluish clay (*a*), more or less laminated, which varies from four inches to six feet in thickness; this is the so-called "Clays of the Cornbrash."

The clay (*a*) contains several species of shells which are rarely met with in the bed below, such as *Sanguinolaria parvula*, Bean, *Cardium latum*, Bean, *Opis triangularis*, Bean, *Belemnites tornatilis*, Phil. The claws and carapace of two Crustacea (*Glyphœa rostrata* and *Glyphœa Birdii*) occur in round argillaceous nodules in the clay at Cayton Bay, where my friend Dr. Murray collected likewise a beautiful specimen of *Hemipedina Woodwardi*, Wr., which he kindly gave me to figure.

Beneath the clay is the Cornbrash, which consists of a hard iron-shot oolite (*b*), of a bluish-grey colour, and often stained with the peroxide of iron. It occurs in masses of an irregular shape, which contain a great many fossils, laid in all directions and firmly cemented together. The shells are so numerous in some of the fossiliferous blocks, that it is impossible to extract one specimen entire without sacrificing many others. It is from this bed, which is only about two feet in thickness, that most of the specimens of the subjoined list were obtained. Beneath the hard bed is (*c*) a softer rock, which is only partially iron-shot, and not so fossiliferous; it is from 18 inches to 2 feet in thickness, and passes into (*d*) a more fissile oolite, easily decomposed when exposed to the atmosphere. The last rests on the upper sandstone and shales of the Inferior Oolite.

Although the Cornbrash of Scarborough is only a thin and unimportant rock, of about five feet in thickness, it has yielded to the working geologists of that locality about 130 species of beautiful fossils, the majority of which were collected at the north side of the Castle Hill. The rock has here been worked out, and will shortly be covered up by the innovations now in progress.

ample details will be found in Prof. John Phillips's comparative sections in the Oolitic and Ironstone series of Yorkshire, Quart. Journ. Geol. Soc. vol. xiv. pp. 88, 89.

My object in the following descriptions is to show the relation of the Grey Limestone to the Cornbrash and Upper Sandstones above, and to the Millepore-bed below, and, from the fauna of the Grey Limestone, to demonstrate that it is the representative of the Middle and Upper divisions of the Inferior Oolite of the south of England, and not, as maintained by my friend Prof. Phillips, the correlative of the Great or Bath Oolite.

*Fossils from the Cornbrash of the Yorkshire Coast, contained in Mr. John Leckenby's Cabinet**.

Belemnites tornatilis, *Phil.*
Nautilus hexagonus, *Sow.*
Ammonites Herveyi, *Sow.* (*A. terebratus*, Phil.; *A. macrocephalus*, Schloth.).

Turbo funiculatus, *Phil.*
—— elaboratus, *Lyc. & Mor.*
Trochus monilitectus, *Phil.*
Purpurina ornata, *Sow.* sp.
Littorina punctura, *Bean*, sp.
Nerinæa cingenda, *Phil.* not *Sow.*
Cerithium gemmatum, *Lyc. & Mor.*
Nerita lævigata, *Phil.* not *Sow.*
—— granulata, *Phil.* not *Sow.*
Pleurotomaria granulata, *Sow.*
Chemnitzia vittata, *Phil.*, sp.
Alaria bispinosa, *Phil.* sp.
Bulla undulata, *Bean.*
Actæonina, sp. n. (tumid undescribed shell).

Ostrea Marshii, *Sow.*
—— spatiosa, *Bean, MS.*
—— Meadii, *Sow.*
—— solitaria, *Sow.*
Gryphæa bullata, *Phil.*
Exogyra mima, *Phil.*
Pecten lens, *Sow.*
—— demissus, *Phil.*
—— arcuatus, *Sow.*
—— cancellatus, *Phil.*
—— fibrosus, *Sow.*
—— vagans, *Sow.*
—— inæquicostatus, *Phil.*
Hinnites gradatus, *Bean, MS.*
Lima rudis, *Phil.*
—— gibbosa, *Sow.* (var. with intermediate costæ).
—— rigidula, *Phil.* sp.
—— duplicata, *Sow.*
Placunopsis, sp. n. (on *Goniomya literata*). *Ostrea granulata* of Mr. Bean's list.
Gervillia aviculoides, ? *Sow.*
Trichites (*Inoceramus* of Mr. Bean's list).
Monotis Braamburiensis, *Phil.* sp.
Perna rugosa, *Goldf.*
Pinna cuneata, *Phil.*
Mytilus sublævis, *Sow.*
Modiola cuneata, *Sow.*
—— imbricata, *Sow.*
—— bipartita, *Sow.*
Modiolarca (sp. nov.).
Leda lachryma, *Sow.* sp.
—— variabilis, *Sow.* sp.
Cucullæa cancellata, *Phil.*
—— clathrata, *Leck.*
—— proxima, *Bean.*
—— abrupta, *Bean.*
Trigonia costata, v. pullus, *Sow.*
—— elongata, *Sow.*
—— signata, *Ag.*
—— clavellata, *Sow.?*
Cardium lobatum, *Phil.*
—— cognatum, *Phil.*
—— latum, *Bean.* (In clay.)
—— citrinoideum, *Phil.*
—— globosum, *Bean.*
Lucina crassa, *Sow.*
—— despecta, *Phil.*
Corbis ovalis, *Phil.*
—— lucida, *Bean.*
Opis Scarburgensis, *Leck.*, sp. n. (a large handsome shell).
—— sp. n. (allied to *O. similis*, Sow.).
Astarte elegans, *Phil.* not *Sow.*
—— extensa, *Phil.*
—— politula, *Bean.*
—— (a species referred by Mr. Bean to *A. lurida*, Sow.)
—— Leckenbyi, *Wr.*, sp. n. (allied to *A. excavata*).
—— sp. n. (A small, thick, sulcate shell, resembling a species in the Kelloway Rock of Wiltshire.)
Unicardium depressum, *Phil.*
Isocardia tumida, *Phil.*
—— minima, *Sow.*
—— nitida, *Sow.*
—— triangularis, *Bean.*
Tellina proletaria, *Bean.*
Quenstedtia lævigata, *Phil.*
Sowerbya triangularis, *Phil.* sp.
Pholadomya Murchisoni, *Phil.*, ? *Sow.*
—— ovalis, *Sow.*
—— acuticostata, *Sow.*

* Most of the fossils in the above catalogue are enumerated in the list made by Mr. Bean in 1838, and published in the 'Annals and Magazine of Natural History,' new series, vol. iii. p. 57. Where alterations have been made, they have been done at the suggestion of my kind friend Mr. Leckenby (with whom I have studied all the species), after a critical examination of most of the original types. Several additions have been made to the list of *Mollusca* by Mr. Leckenby, from specimens contained in his magnificent collection. I have been able to add two *Echinodermata—Hemipedina Woodwardii*, Wr., kindly presented by my worthy friend Dr. Murray of Scarborough, and *Pseudodiadema pentagonum*, M'Coy, collected by Mr. Leckenby.

Pholadomya simplex, *Phil.*
—— nana, *Phil.*
Homomya crassiuscula, *Lyc. & Mor.*
Pleuromya? recurva, *Phil.* sp.
Goniomya V-scripta, *Sow.* sp.
Myacites calceiformis, *Phil.*
—— modica, *Bean, MS.*
—— decurtatus, *Phil.* sp.
—— securiformis, *Phil.* sp.
Gresslya peregrina, *Phil.* sp.
Anatina undulata, *Sow.*
—— plicatella, ? *Lyc. & Mor.*
—— parvula, *Bean.*
Gastrochæna tortuosa, *Sow.*
Pholas costellata, *Sow.*

Rhynchonella varians, ? *Schloth.*
Terebratula obovata, *Sow.*
—— lagenalis, *Schloth.*
—— intermedia, *Sow.*

Serpula intestinalis, *Phil.*
Serpula squamosa, *Phil.*
—— clava, *Bean.*

Glyphæa rostrata?, *Phil.*
—— Birdii*, *Bean.*

Pseudodiadema pentagonum, *M'Coy.*
—— vagans, *Phil.*
Hemipedina Woodwardii, *Wright.*
Echinobrissus clunicularis, *Lhwyd.*
—— orbicularis, *Phil.*
Holectypus depressus, *Lamk.*

Astræa? Dunnii, *Bean.*
Caryophyllia, sp.

Tubipora? acervalis, *Bean.*
—— incrustans, *Bean.*
Spiropora straminea, *Phil.*
Cellaria Smithii, *Phil.*
Flustra, sp.

Spongia floriceps, *Phil.*
—— papillosa, *Bean.*

No. 2, the first bed beneath the Cornbrash, is a grey laminated sandstone with carbonaceous markings and ferruginous stains. It exhibits much cross-bedding, is intersected by iron-stone bands, and forms a bluff in the bay. This bed is nearly horizontal for a considerable distance, and is covered with débris from the cliff. It measures from 30 to 40 feet, and is apparently non-fossiliferous.

No. 3. A grey siliceous rock which forms the base of bed No. 2; it weathers into irregular nodules, and forms a prominent band in the cliff. It measures 4 feet, and is apparently non-fossiliferous.

No. 4. Grey clays, which are indurated, and break up into cuboidal fragments. 6 feet.

No. 5. A grey, laminated, ferruginous sand-rock, which readily disintegrates when exposed to the atmosphere. It presents numerous ochraceous and brownish stains. No fossils. 8 feet.

No. 6. A brown ferruginous sand-rock, very irregularly bedded, and richly charged with the peroxide of iron: in some parts it is pisolitic. This bed forms a good limit-line in the section, from its hard ferruginous character. It measures only about 2 feet.

No. 7. A whitish sandstone, with an irregular waving lamination. It contains numerous carbonaceous laminæ in its upper portion, with the remains of the stems of plants, some of considerable length. It becomes waved and shaly beneath, and exhibits a very irregular section below, where it passes into the next bed. It measures about 4 feet.

No. 8. A yellowish-grey, regular-bedded sandstone, which projects on the strand to high-water mark. This rock exhibits numerous carbonaceous seams, in a fine grey shale, with fragments of stems in its lower layers. 9 feet.

No. 9. Grey sandy shales with interstratified layers of sandstone, waved and irregular in the upper and under strata. 10 feet.

The beds above-described, from No. 2 to No. 9 inclusive, belong to the upper shales and sandstones. The bed which follows is the

* These *Crustacea* require re-examination.

"grey limestone" or the so-called "Bath Oolite," which represents the *Humphriesianus-zone* of the Inferior Oolite.

No. 10. Grey limestone rises on the sea-shore, and may be easily overlooked if it happens to be covered with débris, although it is always visible in the cliff, from which fossiliferous fragments are constantly falling on account of the weathering of the underlying shales.

The grey limestone at Gristhorpe forms a very inconsiderable stratum, about 3 feet in thickness; but at the White Nab and at Cloughton Wyke, and in Haiburn and Stainton Dale cliffs, it attains a considerable thickness, and admits of a general division into six beds, which, in descending order, may be thus enumerated *:—

	ft.	in.
a. Alternate layers of argillaceous oolite and nodular ironstone. About	3	0
b. Dark clay with *Monotis* and *Gervillia.* From 8 inches to	1	0
c. Nodular ironstone, many of the nodules containing *Ammonites Blagdeni,* &c. From 6 inches to	1	0
d. Hard, dark, ferruginous clay, with Saurian bones and fossil shells	2	0
e. Close-grained greyish oolite, in parts iron-shot	5	0
f. Hard, blue, thick-bedded limestone, used for building From 12 to	18	0

The inferior layer of *a* at Cloughton contains *Perna rugosa*, Goldf., and other shells. *b* is well exposed on the shore near Scarborough, where *Gervillia acuta*, Phil. (*G. consobrina*, d'Orb.), forms the dominant shell. Many of the large nodules of *c* contain *Ammonites Humphriesianus*, *A. Blagdeni*, and *A. Braikenridgii*. Saurian bones (*Plesiosaurus* and *Ichthyosaurus*) have been found in *d*, near Scarborough; and the same bed at Cloughton affords many fossil shells. Few, if any, fossils have been found in *e*; and the lower and middle portions of *f* are equally unproductive; the upper part of *f* contains *Belemnites giganteus*, Schloth., *Myacites calceiformis*, Phil., *Gresslya decurtata*, Phil., *Chemnitzia Scarburgensis*, Lyc., and the long muricated spines of *Rhabdocidaris maxima*, Goldf. The White Nab and Cloughton are the best localities for obtaining fossils. Many of the beds are exposed at the south side of Scarborough Bay at low water; and nearly opposite the Cliff Bridge, at low tides, an anticlinal axis is visible, extending N.E. to S.W., by which the beds of grey limestone suddenly incline 45° to the south, and the Kelloway Rock and Oxford Clay of the Castle Hill dip to the north.

Fossils from the Grey Limestone, in Mr. Leckenby's Cabinet, &c.

Belemnites giganteus, *Schloth.*
Ammonites Humphriesianus, *Sow.*
—— Blagdeni, *Sow.*
—— Braikenridgii, *Sow.*
Ammonites Parkinsoni, *Sow.* (Scarborough Museum. This specimen was collected in the upper beds of the grey limestone at White Nab.)

* Professor Williamson has given a most accurate description of the "Grey Limestone," with like subdivisions, in his valuable paper "On the distribution of Fossil Remains on the Yorkshire Coast," Trans. Geol. Soc. 2nd series, vol. v. p. 223.

Turbo elaboratus, *Lyc. & Mor.*
—— Phillipsii, *Lyc. & Mor.*
Trochus monilitectus, *Phil.*
—— Leckenbii, *Lyc. & Mor.*
Phasianella striata, *Sow.*
Eulima lævigata, *Lyc. & Mor.*
Cerithium Beanii, *Lyc. & Mor.*
—— gemmatum, *Lyc. & Mor.*
Chemnitzia Scarburgensis, *Lyc. & Mor.*
—— vetusta, *Phil.*
Natica adducta, *Phil.*
—— cincta, *Lyc. & Mor.*
Alaria Phillipsii, *Lyc. & Mor.*
Actæonina glabra, *Phil.*

Ostrea flabelloides, *Lamk.*
——, a large flat species.
Lima, sp. n. A very fine-ribbed shell.
Placunopsis inæqualis, *Phil.* sp.
Pecten Saturnus, *d'Orb.*
—— demissus, *Phil.*
Lima duplicata, *Sow.*
Avicula Muensteri ? *Lyc. & Mor.*
—— ornata, *Goldf.*
Monotis Braamburensis, *Phil.* sp.
Gervillia acuta, *Sow.*
Pteroperna plana, *Lyc.*
Perna rugosa, *Goldf.*
—— mytiloides, *Goldf.*
Pinna cuneata, *Phil.*
—— cancellata, *Lyc. & Mor.* (Junior of *P. cuneata*).
Modiola ungulata, *Young & Bird.*
—— imbricata, *Sow.*
—— cuneata, *Sow.* (Dwarfed var.)
Mytilus pulcherrimus, *Roemer.*
Cucullæa cancellata, *Phil.*
—— reticulata, *Phil.*
Trigonia costata (var. pulla), *Sow.*
—— signata, *Ag.* (*T. decorata*, Lyc.)
Cyprina, sp. n.
Cardium ? semiglabrum, *Phil.*
Lucina despecta, *Phil.*
Astarte minima, *Phil.*
—— elegans, *Phil.*, not *Sow.*
Isocardia nitida, *Phil.*
—— cordata, *Buckm.*
Unicardium depressum, *Phil.* sp.
Quenstedtia lævigata, *Phil.* sp.
Myacites calceiformis, *Phil.*
—— Beanii, *Lyc. & Mor.*
—— Goldfussii, *Lyc.*
Goniomya V-scripta ? *Sow.*
Gresslya peregrina, *Phil.*
Pholadomya Heraulti, *Ag.*
Homomya crassiuscula, *Lyc. & Mor.*
Thracia, sp. n.
Pholas pulchralis, *Lyc. & Mor.*
Mya ? æquata, *Phil.*

Vermicularia nodus, *Phil.*
Serpula plicatilis, *Goldf.*
—— sulcata, *Sow.*
—— intestinalis, *Phil.*

Rhabdocidaris maxima ?, *Münst.*
Pseudodiadema depressum, *Ag.*
—— vagans, *Phil.*
Astropecten Leckenbyi, *Wr.*, sp. n.
—— Scarburgensis, *Wr.*, sp. n.
Ophiura Murravii, *Forbes.*

No. 11. Forms the uppermost bed of the Lower sandstones and shales, assuming that the Grey limestone is to be regarded as the frontier-bed between these two great arenaceous lacustrine deposits of the Inferior Oolite of Yorkshire.

The rock beneath the grey limestone is a greenish laminated sandstone, divided by joints, and beautifully intersected by thin carbonaceous seams, with the stems and leaves of plants, and much dark carbonaceous matter in the lower layers of the bed. 6 feet 6 inches. It rests on—

No. 12. A dark carbonaceous shale. 1 foot.

No. 13. A dark grey clay. 4 feet.

No. 14. A greyish sandstone above, with greenish clays below, full of dark carbonaceous matter. 2 feet.

No. 15. Green and grey sandy clays, full of the fragments of plants, with portions of the stems of *Cycadeæ*. In this bed, my friend John Leckenby, Esq., collected several specimens of *Unio distortus*. I saw impressions of shells, but found none. It measures 3 feet.

No. 16. Black shaly bed, full of carbonaceous matter, with seams of imperfect coal and vegetable remains. 1 foot.

No. 17. Finely laminated grey shales and sandstones, with carbonaceous laminæ. 1 foot 6 inches.

No. 18. Dark, laminated, carbonaceous, shaly bed, with stems in a dark laminated shale and sand, passing downwards into dark clays with the shells and impressions of Unios. It is about 4 feet thick.

No. 18 *a*. A dark shale with ironstone. 2 feet.

No. 18 *b*. Grey laminated sandstone. 1 foot.

No. 19. The Gristhorpe plant-bed, rises opposite the pillar; it consists of dark grey shale, containing within its laminæ a great number of magnificent fossil plants in a fine state of preservation, in a thickness of 2 feet.

The same bed is seen *in situ* at Red Cliff, where it gradually declines to the shore. The shale is underlain by a seam of imperfect coal from 6 to 8 inches in thickness.

This bed may be said to be the chief herbarium for most of the species of fossil plants from the lower sandstones and shales of the coast of Yorkshire, which are figured in the works of Prof. Phillips and in the 'Fossil Flora' of Lindley and Hutton.

No. 20. Fine laminated sandstone, exhibiting wavy layers when divided; it forms a ledge which runs out to sea, and constitutes the basal rock of the pillar on the island. It presents a low escarpment to the north. The strata are separated by soft sandy marly partings, which cause divisions in the bed in consequence of the wearing away of the softer laminæ. I found no fossils. 12 feet.

No. 21. A marine bed, formed of a brown, nodulated, ferruginous sand-rock with ironstone-nodules, which project from the weathered surface of the bed. It contains a few marine shells, as *Pholadomya Sæmanni*, Lyc., *Cardium lævigatum*, Lyc., *Trigonia costata*, Sow. 5 ft.

No. 22. A white and grey laminated sandstone with shelly partings. 4 feet.

No. 23. Ironstone-rock, full of iron-nodules, with partings of clay, containing marine shells. *Lima interstincta*, Phil., and *Serpula intestinalis*, Phil., were collected from it. 2 feet.

No. 24. Lacustrine bed: greyish laminated shale, with the remains of plants, interstratified with bands of sandstone. Few specimens are obtained from this bed. 4 feet.

No. 25. A dark-grey clay, exposed at low water, and containing the remains of plants in its upper portion, and comparatively unfossiliferous in its lower division. This bed is well seen in the coast-section at Haiburn and Stainton Dale cliffs, where it becomes more sandy, and passes into the block-sandstone which rests upon the Millepore-bed. Mr. Leckenby collected *Cypris? concentrica*, Bean, from the clays of this bed at Gristhorpe, where it is about 10 feet thick.

No. 26. The marine bed. The Millepore-bed rises in the form of a reef beyond the grey clays of the preceding bed, exhibiting another change from lacustrine to marine conditions. It is an obliquely laminated partly oolitic rock, containing oxide of iron in the partings, and is full of the fragments of *Crinoidea*, *Polyzoa*, *Serpulæ*, and the plates and spines of *Echinodermata*. This rock is likewise exposed at Red Rock, Ewe Nab, Cloughton Wyke, Haiburn Wyke, and Stainton Dale Cliffs, and the Peak. It forms

one of the most persistent fossiliferous bands in the coast-section, and may be traced continuously from Cloughton Wyke to Peak Point, as we sail along the shore. It forms an anticlinal at the south side of Cayton Bay and at Red Rock Point. At Cloughton Wyke it is well exposed, where it measures about 10 feet. The lower portion is shelly and ferruginous, and emits a sulphurous odour; and from this part of the rock Mr. Leckenby has collected the following species of *Mollusca*.

Fossils from the Millepore-bed in Mr. Leckenby's Cabinet.

Natica adducta, *Phil.*
Nerita pseudocostata, *d' Orb.*
Chemnitzia vetusta, *d' Orb.*
Turritella quadrivittata, *Phil.*
Alaria Phillipsii, *Lyc. & Mor.*
Turbo elaboratus, *Bean.*
Actæonina glabra, *Phil.*
Cerithium Leckenbyi, *Wr.*, sp. n.

Pecten Saturnus, *d' Orb.*
—— demissus, *Phil.*
Lima duplicata, *Sow.*
Gervillia lata, *Phil.*
—— Hartmanni, *Goldf.*
Pinna cancellata, *Phil.*
Mytilus tumidus, *Lyc. & Mor.*
Modiola imbricata, *Sow.*
—— cuneata, *Sow.*
—— Leckenbyi, *Mor.*
Trigonia angulata, *Sow.*
Cardium striatulum, *Phil.*
Astarte minima, *Phil.*
Pullastra recondita, *Phil.*
Unicardium gibbosum, *Lyc.*
Pholadomya Heraulti, *Ag.*
—— Sæmanni, *Lyc. & Mor.*
Myacites oblonga, *Wr.*, sp. n.
—— decurtata, *Phil.*
Ceromya Bajociana, *d' Orb.*
Gresslya adducta, *Phil.*
Pholas costellata, *Lyc. & Mor.*
Goniomya literata, *Sow.*

The Millepore-bed attains a considerable development at Cromebeck and Whitwell, near Castle Howard station, on the York and Scarborough railway, where it is a thick-bedded oolitic limestone, resembling the freestones of the Inferior Oolite in Gloucestershire. The rock has long been worked at Cromebeck for economic purposes, and is admirably exposed in an extensive range of quarries. The limestone of the Inferior Oolite is here overlain by a soft greyish sandstone, about 6 feet thick, which forms the uppermost bed; beneath this is an extremely hard, siliceous, slaty sandstone, 18 inches thick, which represents part of the "Block-sandstone," No. 3 of the Peak, and caps the thick-bedded oolitic limestone, which is the inland representative of the Millepore-rock of the coast-section. The cream-coloured oolitic limestone dips to the north at an angle of 2°, and is in some parts composed of large grains, in others of small, and in others it is soft and fine-grained. In lithological character, the rock and its bedding resemble the thick-bedded freestones of the West of England. Its upper beds, from 10 to 12 feet thick, are quarried for building-stone, and burned for lime; and the lower portion is a grey oolitic limestone, which is largely quarried for road-material. It attains a thickness of 10 feet, and rests upon a hard dark-blue shale, No. 2 of the Boring-section. I have prepared the following list from a series of specimens obtained from this rock by my friend W. Reed, Esq., of York, and contained in his collection. I found several of the species *in situ* during the excursion which I made to the quarries in August last.

Hinnites abjectus, *Phil.*
Limea duplicata, *Sow.*
Ostrea sulcifera, *Bean, MS.*
Lima proboscidea, *Sow.* (oblong var.).
Gryphæa sublobata, *Desh.*
Pinna cuneata, *Phil.*
Lima bellula, *Lyc. & Mor.*
Pecten Saturnus, *d'Orb.*
Mytilus ungulatus, *Y. & B.*
Modiola imbricata, *Sow.*
Ceromya Bajociana, *d'Orb.*
Pteroperna plana, *Lyc.*
Gervillia Hartmanni, *Münst.*
Trigonia costata, *Sow.* (small var.).
—— gemmata, *Lyc.*
—— angulata, *Sow.*
—— duplicata, *Sow.*
Cypricardia cordiformis, *Desh.* (Cold Comfort, *var.*)
Arca (moulds).

Terebratula maxillata, *Sow.*

Pygaster semisulcatus, *Phil.*
Clypeus Michelini, *Wright.*
Hyboclypus agariciformis, *Forbes.*
Stomechinus germinans, *Phil.*

The Lower Sandstones which crop out on the north bank of the railway between Hutton and Castle Howard stations have recently been worked for ironstone, and contain about 33 per cent. of iron. A boring has been made at Mount Pleasant Hill, close to the Cromebeck quarries, through the Inferior Oolite and underlying shales and sandstones, down to the shales of the Upper Lias. This boring-section affords an insight into the relative thickness of the shales and sandstones which lie between the Millepore-bed and the Alum-shale; and therefore I give it in detail. The examination was made by the engineer who had charge of the works*.

		ft.	in.
Millepore-bed	Inferior Oolite limestone (Millepore-bed)	20	8
	Hard blue shale	4	0
	White sand	9	0
	Ironstone	0	8
	Nodular ironstone	0	4
Dogger-beds	Red Sandstone	9	0
	Freestone dogger	2	0
Blue Wick sands.	Hard black shale	13	0
	Clay-ironstone (Hydraulic limestone?)†	3	4
	Dry blue shale	8	0
	Top band of ironstone, fossiliferous‡	5	0
	Hard callous shales	2	8
	Ironstone	1	0
	Yellow dry shale	4	6
Basement- or Striatulus-bed	Blue dry shale	4	0
	Black dry shale	0	6
	Blue dry shale	6	0
	Black hard shale	0	6
Upper Lias shales.	Alum-shale	2	6
	Hard dry shale	6	0
	Dry sandy shale	2	0
	Black clay (pure)	3	0
	Light-coloured clay	2	6
		110	2

* The station-master to Castle Howard Station kindly informed me of this section, and supplied me with a copy thereof.

† This bed is now being used in the manufacture of cement.

‡ This is the bed that is raised for ironstone. Its fossils resemble those ob-

D. *Sections of the Inferior Oolite in Somersetshire and Dorset.*—In some parts of Somersetshire the beds under consideration are more or less developed.

1. *Glastonbury Tor.*—A solitary outlier of the Upper Lias Sands is seen at Glastonbury Tor. This remarkable cone is about 500 feet high (aneroidal measurement*), and presents the following Section:—

		feet.
Brown and yellow sands, incoherent where exposed		190
Light-coloured Upper Lias ragstones, containing *Ammonites bifrons, A. Holandrei, A. radians, A. falcifer, A. communis,* and *A. crassus*		14
Marlstone-rock, with *Ammonites margaritatus,* about....		15
Marlstone-sands, well exposed where cut through by the road		30
Middle Lias (concealed)..........	probably	250
Lower Lias (concealed)..........		

2. *Yeovil.*—Around Yeovil the Upper Lias Sands are equally well developed, and admirably exposed in numerous sections in the roads, lanes, and railway-cuttings, where they vary in thickness: at the Half-way House the sands were bored, in sinking a well, to a depth of 140 feet before reaching the Lias Clay; near Yeovil they are traversed by layers of large nodules at varying intervals of from 4 to 6 feet. These nodules rarely contain fossils, but are so much indurated that they are used as building-stone in the Central Somerset Railway. At Down Cliff, on the coast of Dorset, similar nodules form a micaceous sandstone, on the surface of which *Ophioderma Egertoni*, Brod., only is found.

The Inferior Oolite, which near Yeovil immediately overlies the sands, is comparatively thin, in consequence of the absence of the thick-bedded limestones which impart such a thickness to this formation in Gloucestershire. It consists of the middle and upper divisions of that formation. The bottom-bed is an extremely hard, crystalline, greyish-coloured limestone, called the "Dew-bed," which is raised for road-material, and contains a few shells and *Polyzoa*, some bones and fossil wood. This is overlain by a shelly, iron-shot, oolitic limestone, extremely rich in fossil shells, and from which nearly all the *Gasteropoda* and *Conchifera* contained in my list were obtained. This is succeeded by an Ammonite-bed, containing many fine specimens of *Ammonites Sowerbyi, A. Braikenridgii, A. concavus* and *A. Dorsetensis*. Above the *Cephalopoda*, come in lighter-coloured, thin-bedded, oolitic limestones, with *Ammonites Parkinsoni, A. Truellei* and *A. Martinsii*, which are overlain by bands of oolitic freestone, interstratified with light-coloured marls. Such is the general character of the three sections which I have examined, and of which I subjoin detailed descriptions.

tained from a similar ferruginous rock at Glazedale. It appears to represent that bed, both lithologically and palæontologically.

* My friend E. H. Day, Esq., of Weston-super-Mare, obtained these measurements by his aneroid barometer.

3. *Henbury Quarry, one mile and a half from Yeovil.*

	ft.	in.
A. Parkinsoni-zone.		
a. Rubbly oolitic ragstone, much broken	3	0
b. Light-coloured oolitic limestone, containing *Ammonites Parkinsoni* and *Belemnites canaliculatus* ..	6	0
c. Hard oolitic ragstone, with *Belemnites* and Pectens	1	6
B. Humphriesianus-zone.		
d. Ammonite-bed, a hard, brown, oolitic limestone, charged with crystallized carbonate of lime, and containing many large *Ammonites*	5	0
e. The Shell-bed; a sandy oolitic limestone composed of soft brown marl, in which are abundantly strewed numerous oolitic grains of the hydrate of iron, and many fossils	4	0
f. The "Dew-bed," a greyish, hard, crystalline limestone.		

The fossils in A are not well preserved. The specimens of *Ammonites Parkinsoni* are chiefly moulds or impressions. Those of *d* are in good preservation; many large slabs are raised entirely covered with *Ammonites concavus*, Sow., which appears to be the dominant shell here. *Ammonites Dorsetensis*, Wr., likewise occurs in this bed. The Shell-bed (*e*) is likewise very rich in *Gasteropoda* and *Conchifera*. I collected *Pleurotomaria actinomphala*, *Purpurina ornata*, *Chemnitzia bicarinata*, *Cucullæa oblonga*, *Gervillia Hartmanni*, *Lima Etheridgii*, *Modiola reniformis*, and *Serpula grandis* in situ.

4. *Half-way House Quarry, three miles from Yeovil.*

	ft.	in.
A. Parkinsoni-zone.		
a. Coarse, brown, oolitic ragstone	3	0
b. Several beds of freestone, alternating with beds of marl; the former used for building	10	0
c. Light-coloured oolitic freestone; building-stone ..	1	6
B. Humphriesianus-zone.		
d. Ammonite-bed, a brown, iron-shot, oolitic limestone, with many large specimens of *Ammonites Dorsetensis*	1	6
e. Light-coloured marl; *Ammonites* and *Conchifera* ..	0	5
f. Brown, coarse, shelly, iron-shot oolite, containing a considerable number of *Conchifera*	3	6
g. The "Dew-bed"; a hard, grey, crystalline limestone, raised for road-mending, about	2	0

The beds of A are not fossiliferous. The alternate layers of freestone and marl represent the Upper Ragstones and Building-freestones (No. 5–7) of Dundry; they yield, however, a very inferior stone. The beds of B are very fossiliferous; *d* has long yielded many large specimens of *Ammonites Dorsetensis* and *Nautilus lineatus*, having

their chambers filled with crystallized carbonate of lime. The light marl (*e*) contains *Ammonites Sowerbyi, Astarte modiolaris, Pecten demissus, Trigonia costata,* and many other bivalved shells. The shell-bed (*f*) contains *Pleurotomaria, Ceromya Bajociana, Terebratula perovalis.* In the "Dew-bed" (*g*) bones and portions of fossil wood are found, although I failed to observe any shells.

5. *Section in the Quarry at Bradford Abbas, Dorset.*

	ft.	in.
A. Parkinsoni-zone.		
a. Light-coloured oolitic ragstone	3	6
b. Light cream-coloured marl	0	5
B. Humphriesianus-zone.		
c. Ammonite-bed; brown ferruginous oolite, much iron-shot, with crystallized carbonate of lime; *Ammonites Sowerbyi* and *A. concavus*	1	0
d. The Shell-bed; a brown, iron-shot oolite, containing many *Gasteropoda* and *Conchifera*	2	4
e. The "Dew-Bed"; greyish, hard, crystalline rock, partly shelly, with *Polyzoa* in nests on the surface..................................	1	6

The ragstone and cream-coloured marl of A are employed for road-material, and contain impressions of *Ammonites Parkinsoni* and many fragments of *Belemnites canaliculatus* and *B. giganteus.* *b* contains many specimens of *Astarte modiolaris* and *Lima semicircularis.* In the zone of *Ammonites Humphriesianus* (B), *c* is very rich in *Ammonites Sowerbyi* and *A. concavus*; and here I found the new *Ammonites Oppeli,* Wr. *d* has yielded most of the *Gasteropoda* and *Conchifera* contained in the annexed list. The "Dew-bed" (*e*) contains *Ceromya Bajociana, Cypricardia cordiformis,* and a species of *Spiropora*; portions of bone and wood have likewise occasionally been found in it.

Fossils from the Humphriesianus Zone of Somerset, contained in my Cabinet.

Belemnites giganteus, *Schloth.*
—— canaliculatus, *Schloth.*
Nautilus lineatus, *Sow.*
—— sinuatus, *Sow.*
Ammonites Sowerbyi, *Mill.*
—— læviusculus, *Sow.*
—— Brocchi, *Sow.*
—— Humphriesianus, *Sow.*
—— Braikenridgii, *Sow.*
—— Blagdeni, *Sow.*
—— Dorsetensis, *Sow.*
—— discus, *Quenst.* (non *Sow.*).
—— concavus, *Sow.*
—— Oppeli, *Wr.*, sp. n.
Chemnitzia lineata, *Sow.*
—— bicarinata, *Wr.*, sp. n.
Chemnitzia multistriata, *Wr.*, sp. n.
—— turritelliformis, *Wr.*, sp. n.
Straparollus spinosus, *Wr.*, sp. n.
Turbo elaboratus, *Bean.*
—— Milleri, *Wr.*
Natica, sp. n.
Neritopsis Bajocensis, *d'Orb.*
Trochus duplicatus, *Sow.*
—— heliacus, *d'Orb.*
Monodonta lævigata, *Sow.*
—— obliquimuricata, *Wr.*, sp. n.
Cirrus nodosus, *Sow.*
Trochotoma calyx, *Phil.*
Pleurotomaria armata, *Münst.*
—— Bessina, *d'Orb.*
—— ornata, *Sow.*

Pleurotomaria fasciata, *Sow.*
—— sulcata, *Sow.*
—— textilis, *Deslong.*
—— princeps, *Deslong.*
—— granulata, *Sow.*
—— actinomphala, *d'Orb.*
—— paucistriata, *d'Orb.*
—— conoidea, *Desh.*
—— gyrocycla, *var.* saccata, *Deslong.*
—— physospira, *Deslong.*
—— Actæa, *d'Orb.*
—— punctata, *Sow.*
—— elongata, *Sow.*
Alaria Phillipsii, *d'Orb.*
Purpurina ornata, *Sow.*
—— Belia, *d'Orb.*
—— Bellona, *d'Orb.*
Cerithium quadrinodosum, *Wr.*, sp. n.
—— spinicostatum, *Wr.*, sp. n.
—— binodoso-lineatum, *Wr.*, sp. n.
Emarginula granulata, *Wr.*, sp. n.
Delphinula.

Ostrea.
Hinnites abjectus, *Phil.*
Pecten barbatus, *Sow.*
—— Dewalquei, *Oppel.*
Pteroperna plana, *Lyc.*
Perna rugosa, *Münst.*
Gervillia Hartmanni, *Goldf.*
Lima Etheridgii, *Wr.*, sp. n.
—— Sandersi, *Wr.*, sp. n.
—— proboscidea, *Sow.*
Myoconcha crassa, *Sow.*
—— striatula, *Goldf.*
Pinna cuneata, *Phil.*
Mytilus acutangulus, *Wr.*, sp. n.
Cucullæa oblonga, *Sow.*
—— cancellata, *Phil.*
Macrodon Hirsonensis, *d'Arch.*
Isoarca tenuicosta, *Wr.*, sp. n.
Cardium lævigatum, *Lyc.*
Unicardium depressum, *Phil.*
—— incertum, *Phil.*
—— gibbosum, *Lyc.*
Trigonia costata, *Sow.*
—— striata, *Sow.*
—— cancellata, *Wr.*, sp. n.
Cypricardia acutangula, *d'Orb.*
—— elongata, *Wr.*, sp. n.
Astarte excavata, *Sow.*
—— rhomboidalis, *Phil.*
—— modiolaris, *Lamk.*
—— elegans, *Sow.*
—— detrita, *Goldf.*
—— obliqua, *Lamk.*
—— trigonalis, *Sow.*
—— recondita, *Phil.*
Opis similis, *Sow.*
Ceromya Bajociana, *d'Orb.*
Pleuromya Jurassi, *Quenst.*
Pholadomya Heraulti, *Ag.*

Terebratula Phillipsii, *Mor.*
—— perovalis, *Sow.*
—— emarginata, *Sow.*
Rhynchonella spinosa, *Schloth.*
—— subtetrahedra, *Dav.*

Montlivaltia Delabechii, *Edw. & Haime.*
—— trochoides, *Edw. & Haime.*
Thamnastræa Defranciana, *Michelin.*

3. The Zone of Ammonites Parkinsoni.

Synonyms.—"Trigonia-grit and Gryphite-grit," Murchison, Geol. of Chelt., 1845, 2nd ed.; H. E. Strickland, Quart. Journ. Geol. Soc. 1850, vol. vi. "Ragstone and Clypeus grit," Hull, Mem. of the Geol. Surv. 1857. "Zone of Ammonites Parkinsoni," Wright, Monogr. of Oolitic Echinoderms, 1856. "Spinosa-stage," Lycett, Cotteswold Hills Handbook, 1858.

Foreign Equivalents.—"Brauner Jura, ε (part)," Quenstedt, Flötzgebirge, 1843. "Parkinsonthone brauner Jura, δ und ε (part)," Quenstedt (Pfizenmeyer). "Calcaire à Polypiers," Terquem, Paléontol. du départ. de la Moselle, 1855. "Die Schichten des Ammonites Parkinsoni," Oppel, Die Juraformation, 1856.

Description.—The series of beds which I include in the zone of *Ammonites Parkinsoni* present different degrees of development in Gloucestershire. In the Northern Cotteswolds, where the best types are seen, they rest on thick-bedded oolitic limestones or freestone, and are overlain by the Fuller's-earth, containing bands with *Ostrea acuminata.* When the upper freestone is absent, they repose as at Turkdean, on the oolite-marl; at Sherborne, on the lower freestone;

and at Burford, on the Upper Lias. This zone is the most persistent of the three subdivisions of the Inferior Oolite, and is the only representative of that formation in the south-eastern parts of the county of Gloucester; for, whereas at Leckhampton Hill the three zones of that formation attain a thickness of 264 feet, at Burford, a distance eastwards of twenty miles, the Inferior Oolite is reduced to less than 20 feet, and is there represented by the Parkinsoni-zone,—the middle and lower zones being altogether absent. In the Northern Cotteswolds, in one or two sections, the following beds may be distinguished.

Fuller's-earth with Ostrea acuminata.

A. *Upper Trigonia-grit.*—Consists of thin-bedded, brown, oolitic ragstones, containing many fossils, chiefly in the form of moulds. *Trigonia costata, T. formosa, T. signata, Rhynchonella spinosa, Ammonites Parkinsoni, A. Martinsii.*

B. *Gryphite-grit.*—Almost entirely composed of the valves of *Gryphæa sublobata,* imbedded in a sandy or calcareous matrix. It is an oyster-bank of greater or less thickness, and is exposed in many sections in the Northern Cotteswolds, but is absent south of Rodborough Hill.

C. *Lower Trigonia-grit.*—A light-coloured, grey or brown, thin-bedded, sandy, oolitic or argillaceous ragstone. It contains in many places a great abundance of fossils. *Clypeus Plotii, Echinobrissus clunicularis, Holectypus depressus, Pedina rotata, Terebratula globata,* and *Lima gibbosa* appear for the first time in this bed.

D. *Chemnitzia-grit.*—This consists of a hard crystalline bed of ragstone above; with bands of marls and clays below. The marls contain *Chemnitzia procera,* fishes' teeth and palates, with remains of *Crustacea.*

Thick-bedded oolitic limestone (*freestone*) *often bored by* Annelida.

This division of the zone of *Ammonites Parkinsoni,* in the works of Murchison, Hull, and Lycett, differs in some important particulars from the description of the same beds given by former authors. The "Clypeus-grit," with *Terebratula globata,* is represented as the uppermost stage of the Inferior Oolite, overlying the Upper Trigonia-grit; but I shall endeavour to demonstrate, by the sections to be described in the sequel, that *Clypeus Plotii* and *Terebratula globata* swarmed in the ocean with *Trigoniæ* long before the Gryphite-grit was deposited; although this sea-urchin and its congeneric *Echinidæ* lived in the waters which deposited the Fuller's-earth, Great Oolite, and Cornbrash, where all these species became extinct. In fact, the fauna of the Lower Trigonia-grit presents a remarkable contrast to that of the freestones on which it rests, both in genera and species. The floor of the sea, formed by the freestones, was indurated; and the solid rock was perforated by the *Annelida* which lived in the Trigonia-stage. Many species likewise of Fish, *Ammonites, Conchifera, Brachiopoda, Echinodermata,* and Corals now appear

for the first time; some only of which lived through subsequent stages and flourished in the Cornbrash, in which they all died out. It is a remarkable fact that the fauna of the Parkinsoni-zone has many more characters in common with that of the Cornbrash than with the lower zones of the Inferior Oolite.

I now proceed to describe sections in which the typical lithological and palæontological characters of the Parkinsoni-zone in the Northern Cotteswolds are well exposed. I intend giving full lists of all the species which I have collected from the different beds of this zone, for the purpose of showing that even in this small formation all the species have not the same duration of life in time.

A. Section I.—Leckhampton Hill.—Northern escarpment.

The Parkinsoni-zone may be said to attain its greatest thickness in this section; but the fossils are not so well preserved as in several other localities. I commence with it, as it presents nearly all the beds which I have enumerated in my general section of the zone.

	ft.	in.
A. *Upper Trigonia-grit.*—A coarse, brown, ferruginous, fragmentary oolitic limestone, much shattered. The fragments contain impressions of *Trigonia costata*, *T. formosa*, and other Conchifers, with *Rhynchonella spinosa*, *Rh. angulata*, and other Brachiopods. In the uppermost layer of the bed, *Ammonites Parkinsoni* lies	7	0
B. *Gryphite-grit.*—A coarse, brown, calcareo-siliceous ragstone, which was an oyster-bank in the Oolitic sea. It is composed of the valves of *Gryphæa sublobata*, Desh., which lie closely piled upon each other, and constitute almost the entire bed . . 8 to	10	0
C 1. Yellow sandy marl or clay, which separates the Gryphite-grit from the underlying Lower Trigonia-grit. It contains many shells: *Pholadomya fidicula*, Sow.; *Gervillia Hartmanni*, Goldf.; *Modiola gibbosa*, Sow.; *Modiola plicata*, Sow.; *Pinna cuneata*, Phil.; *Terebratula perovalis*, Sow.	0	4
C 2. *Lower Trigonia-grit.* — A light-coloured rubbly oolite, containing many fossils, chiefly moulds of *Gasteropoda* and *Conchifera* . . . . 2 to	4	0
D. *The Chemnitzia-grit.*—A hard ragstone above, and soft marl below:—		
1. Hard crystalline ragstone, close-grained and non-fossiliferous.		
2. Light-coloured marls with *Chemnitzia procera*, Deslong.		
3. Stiff brownish clay.		

Fossils of A. *Upper Trigonia-grit.*

Belemnites canaliculatus, *Schloth.*
—— abbreviatus, *Miller?*
Nautilus obesus, *Sow.*
—— lineatus, *Sow.*
Ammonites Parkinsoni, *Sow.*
—— Martinsii, *d'Orb.*
Moulds of Nerinæa, Pleurotomaria, Natica, and Chemnitzia.
Trigonia costata, *Sow.*
—— formosa, *Lyc.*
Trichites undulatus, *Lyc.*
Homomya gibbosa, *Sow.*
Pholadomya Heraulti, *Ag.*
—— Devalquei, *Lyc.*
Lima proboscidea, *Sow.*
—— gibbosa, *Sow.*
Terebratula emarginata, *Sow.*
Rhynchonella spinosa, *Schloth.*
—— concinna, *Sow.*

Fossils of B. *Gryphite-grit.*

Lima proboscidea, *Sow.*
Gryphæa sublobata, *Desh.*
Pholadomya Heraulti, *Ag.*
Pholadomya fidicula, *Sow.*

Fossils of C. *Sandy clay.*

Ammonites læviusculus, *Sow.*
Pholadomya fidicula, *Sow.*
Gervillia Hartmanni, *Goldf.*
Modiola plicata, *Sow.*
Modiola gibbosa, *Sow.*
Pinna cuneata, *Phil.*
Terebratula perovalis, *Sow.*

The fossils contained in the Lower Trigonia-grit (C 2) and the Chemnitzia-grit (D) of Ravensgate Hill are so much better preserved than the shells from the same beds at Leckhampton, that I shall give the lists of these beds when I describe the Ravensgate section, the species being identical in both localities.

Section II.—Ravensgate Hill.

The Upper Trigonia-grit and nearly the whole of the Gryphite-grit have been denuded from the upper part of Ravensgate Hill, which is capped by about 18 inches of light-coloured rubbly oolite, consisting of brashy layers of an oolitic mudstone, loosely cemented by an argillaceous matrix, and containing a few valves of *Gryphæa sublobata*. This is underlain by ragstone 1 foot thick, resting on a band of yellowish clay measuring from 12 to 18 inches.

	ft.	in.
B. Rubbly oolite above, ragstone in the middle, and yellow clay below. The entire bed, which represents the lower portion of the Gryphite-grit, is about ..	4	0
C. *Lower Trigonia-grit.*—A fine-grained sandy oolite, freely speckled with ferruginous grains of the silicate of iron. It is a very fossiliferous bed; and the numerous shells which it contains are sometimes well preserved. It measures	3	0
D. *Chemnitzia-grit.*—Consisting of		
1. A hard, close-grained, oolitic ragstone, which becomes flaggy in parts, and is apparently non-fossiliferous. From 1 foot to	1	6
2. A light-coloured marl, extremely friable, and containing Fishes' teeth, palates, and *Chemnitzia.* From 1 foot to	1	6
3. Yellowish or brownish clay, streaked with ferruginous laminæ towards the base, and containing Fishes' teeth. 1 foot to	1	6

Oolitic freestones, in large bedded blocks, with vertical joints.

Fossils of C. Lower Trigonia-grit.

Ammonites læviusculus, *Sow.*
—— Sowerbii, *Miller.*
Belemnites giganteus, *Schloth.*
—— abbreviatus, *Miller.*

Natica adducta, *Phil.*
—— sp. n.
Monodonta lævigata, *Sow.*
Pleurotomaria fasciata, *Sow.*
Trochotoma carinata, *Lyc.*
Chemnitzia, sp. n.

Trigonia costata, *Sow.*
—— formosa, *Lyc.**
Pholadomya fidicula (var. Zieteni), *Ag.*
—— Heraulti, *Ag.*
—— media, *Ag.*
—— ovulum, *Ag.*
Homomya crassiuscula, *Lyc.*
Myopsis dilata, *Phil.*
Cercomya pinguis, *Ag.*
Goniomya angulifera, *Sow.*
Pleuromya elongata, *Ag.*
—— tenuistriata, *Ag.*
Gresslya latirostris, *Ag.*
—— abducta, *Phil.*
—— conformis, *Ag.*
Ceromya Bajociana, *d'Orb.*
Trichites undulatus, *Lyc.*
Gervillia Hartmanni, *Goldf.*
—— tortuosa, *Deslong.*
Quenstedtia oblita, *Phil.*
Cardium striatulum, *Phil.*
—— lævigatum, *Lyc.*
Corbicella tumidula, *Lyc.*
Unicardium depressum, *Phil.*
Astarte elegans, *Sow.*
—— excavata, *Sow.*
Opis cordiformis, *Lyc.*
Tancredia donaciformis, *Lyc.*
Macrodon Hirsonensis, *d'Arch.*
Cucullæa oblonga, *Sow.*
Avicula digitata, *Deslong.*
Cypricardia cordiformis, *Desh.*
Isocardia cordata, *Buckm.*
Pinna cuneata, *Phil.*
—— ampla, *Sow.*
Modiola plicata, *Sow.* (M. Sowerbii, *d'Orb.*)
—— bipartita, *Sow.*
—— gibbosa, *Sow.*
—— imbricata, *Sow.*
Lima compressa, *Wr.*, sp. n.
—— sulcata, *Münst.*

Terebratula impressa, *Dav.* (T. Meriani, *Oppel.*)
—— Wrightii, *Davids.*
Rhynchonella concinna, *Sow.*
—— spinosa, *Schloth.*

Hyboclypus caudatus, *Wright.*
Clypeus Hugii, *Ag.*

Thecosmilia gregaria, *Edw. & Haime.*
Isastræa tenuistriata, *Edw. & Haime.*
Thamnastræa Defranciana, *Michelin.*
—— Terquemi, *Edw. & Haime.*
Anabacia orbulites, *Lamour.*
Calamophyllia, sp.
Latomæandra Davidsonii, *Edw. & Haime.*

* I have to thank my valued friend, Dr. JOHN LYCETT, for the following note on *Trigonia formosa*:—

Trigonia formosa, Lycett (Syn. *Lyrodon striatum*, Goldf. Petref. tab. 137. fig. 2; *Trigonia striata*, Quenstedt, Jura, tab. 46. fig. 2, not *Trigonia striata*, Sow.).—Shell ovately trigonal, with a low convexity; the umbones are elevated and recurved; the superior border is lengthened and concave, sloping obliquely downwards; the area is concave, rather narrow, with a mesial oblique furrow bordered by two tuberculated carinæ and crossed by densely arranged transverse striations; the lanceolate postligamental space is very much lengthened and excavated. The crenulated rows of costæ upon the other portion of the shell are arranged in a manner similar to those of *T. striata*; but they are less elevated, and the smooth interstitial spaces are wider. This handsome species has generally been mistaken for *T. striata*, owing chiefly to the very indifferent specimens which were represented upon Table 237 of the 'Mineral Conchology,' and the insufficient description appended; a succinct description of *T. striata* will be the most ready means of showing the specific distinctions which characterize the two shells. *T. striata* has the general figure subquadrate, owing chiefly to the great breadth of the flattened area at its posterior extremity, and the nearly horizontal position of the little lanceolate space posterior to the ligament. Agassiz remarks, upon its subquadrate figure, that he should have been inclined to place it with his section "Quadratæ," if it were not furnished with a distinct carina, separating the area from the costated portion of the shell, as exists in the "Clavellatæ" generally. The area is very large, flattened or even slightly convex; its breadth at the posterior border is equal to the entire breadth of the costated portion of

Fossils of D 2, 3. *Chemnitzia-grit.*

Chemnitzia procera, *Deslong.*	Sphærodus; teeth.
Nerinæa.	Squalus; teeth.

Section III.—At Cold Comfort.

A roadside excavation at Cold Comfort, made for extracting road-material, has exposed a very rich upper bed of this zone. The abundance and fine preservation in which the shells of *Perna rugosa* are here found has obtained for this section the name of the "Perna-bed," as this species has not yet been found in numbers in any other locality in this district.

It is probable likewise that the Perna-bed may represent a higher portion of the Upper Trigonia-grit than that exposed at Leckhampton Hill. The reasons for this opinion are these:—It contains many species of *Conchifera* and *Gasteropoda* not found in the Trigonia-grit of the latter locality; moreover the *Trigonia costata* of the Perna-bed belongs to a well-marked permanent variety of that species, which has been designated by the name *tenuicostata.*

		ft.	in.
A 1.	Upper ragstone, consisting of hard fragments of oolitic limestone, which form a coarse rubbly rock traversed by a fossiliferous layer	4	0
A 2.	The Perna-bed is a hard greyish mudstone, slightly oolitic, and full of shells and of shelly fragments in the form of crystallized carbonate of lime. It breaks with an uneven and uncertain fracture....	0	6

The Perna-bed rests upon a non-fossiliferous layer, which passes into another band of rock covered with *Serpula flaccida*, Goldf., on the under side of the stone.

		ft.	in.
A 3.	A hard-grained oolitic limestone, the recently fractured surface of which glistens with crystalline particles or fragments of shells. The small portion exposed is non-fossiliferous. This rock was formerly extracted for road-material. Thickness probably	8	0

the shell; it is equal to three-fifths of the length of the marginal carina, and nearly twice as long as the lanceolate space; the small lanceolate space is smooth and flattened; the marginal and inner carinæ are delicate, without tubercles or varices, and are only indented by the fine striations which cross the area and pass over them. The costated portion of the shell is narrow, being only slightly wider than the area; and the general figure of the shell is very short, or truncated posteriorly; the umbones are not recurved, and the marginal carina is nearly straight.

Both species occur at Dundry; and *T. striata* is, in the Inferior Oolite, the prevailing representative of the genus throughout Somersetshire, Dorsetshire, and in the Province of Calvados; but it does not appear to have extended into the Cotteswold sea, where the little group of species allied to *T. striata* is represented, throughout all the beds of the formation, by *T. formosa.* The figure in the 'Petrefacta' of Goldfuss represents the characters of *T. formosa* less prominently than the Cotteswold specimens. The figure of Quenstedt must be regarded as a variety of *T. formosa*, with widely separated rows of costæ; and this is the aspect which it assumes in the sands of the Upper Lias in Gloucestershire.—J. L.

Fossils of A 1. *Ragstone.*

Lima proboscidea, *Sow.*
Ostrea flabelloides, *Lamk.*
Lima pontonis, *Lyc.*
Terebratula Wrighti, *Davids.*

Fossils of A 2. *Perna-bed.*

Ammonites Edouardianus, *d'Orb.*
Pleurotomaria ornata, *Defrance.*
Purpurina Belia, *d'Orb.*
Perna rugosa, *Münst.*
Gervillia prælonga, *Lyc.*
—— tortuosa, *Phil.*
Trigonia costata, *Sow.*, var. tenuicostata.
—— formosa, *Lyc.*
—— signata, *Ag.* (T. decorata, *Lyc.*)
—— duplicata, *Sow.*
—— gemmata, *Lyc.*
—— costatula, *Lyc.*
Cardium striatulum, *Phil.*
—— lævigatum, *Lyc.*
Trichites undulatus, *Lyc.*
Homomya crassiuscula, *Lyc.*
Leda inflata, *Wr.*, sp. n.
Macrodon Hirsonensis, *d'Archiac.*
Cucullæa cancellata, *Phil.*
—— lævis, *Buckm.*
Cypricardia cordiformis, *Desh.*
Pecten articulatus. (P. Dewalquei, *Opp.*)
—— annulatus, *Sow.*
Hinnites tuberculatus, *Goldf.*
Terebratula Wrightii, *Davids.*
Serpula filaria, *Goldf.*
—— flaccida, *Goldf.*
Hyboclypus caudatus, *Wright.*
Thamnastræa Mettensis, *Edw. & Haime.* (In large flat masses on the valves of *Perna rugosa.*)
Montlivaltia. (Adherent to *Pernæ.*)

Fossil fruits, belonging to two or three species, have been found, by Mr. William Jenkins, in the Perna-bed.

Section IV.—Birdlip Hill.

The road from Birdlip to Gloucester exposes a section of the Lower Trigonia-bed, which rests upon thick-bedded oolitic limestone, and is overlain by the lower portion of the Gryphite-grit. The upper portion of that oyster-bank has been here denuded; but the lower portion is seen *in situ* in a quarry about 150 yards from the turnpike on the road to Cheltenham. It rests on the Trigonia-bed, which consists of a coarse, light-coloured, fragmentary oolitic limestone, containing many Conchifers, Brachiopods, and Echinoderms, and separated from the freestone below by a band of clay. The lower Trigonia-bed here assumes the character which it presents in so many other points of the southern and eastern Cotteswolds, where it has been called "Clypeus-grit," from its containing many specimens of *Clypeus Plotii.* It must be remarked, however, that this Clypeus-grit is not, as it has been figured and described by some authors, a bed *superior to the upper Trigonia-grit* of Leckhampton; but is, in fact, the equivalent of the lower Trigonia-bed in the preceding sections. Where it forms the uppermost stratum of the Inferior Oolite, immediately underlying the Fuller's-earth, either the Upper Trigonia-grit and Gryphite-grit have been denuded, and are absent, or, through the thinning out or absence of the Gryphite-grit, the two Trigonia-beds have come into juxtaposition and formed one Trigonia-grit.

Fossils of the Lower Trigonia-grit.

Trigonia costata, *Sow.*
—— formosa, *Lyc.*
Lima gibbosa, *Sow.*
Pholadomya Heraulti, *Ag.*
—— media, *Ag.*
—— ovulum, *Ag.*

Terebratula globata, *Sow.*
Rhynchonella spinosa, *Schloth.*
Pedina rotata, *Wright.*
Stomechinus intermedius, *Ag.*
Echinobrissus clunicularis, *Lhwyd.*
Holectypus depressus, *Lamk.*
—— hemisphæricus, *Des.*
Clypeus Plotii, *Klein.*
—— Hugii, *Ag.*
Anabacia orbulites, *Lamour.*
Cladophyllia, sp. n.
Isastræa tenuistriata, *Edw. & Haime.*
Thecosmilia gregaria, *Edw. & Haime.*

In the Stroud district, the zone of *Ammonites Parkinsoni* is well developed, and in some places richly fossiliferous. Among these localities, Painswick Hill, Rodborough Hill, Selsey Hill, Scar Hill, and Culver Hill near Nailsworth, may be enumerated as affording good sections.

The Parkinsoni-zone or ragstone, at Painswick Hill, according to Mr. Hull, "is well developed, becomes very sandy towards the base, and contains a bed of siliceous sand of considerable thickness. The beds are very fossiliferous, containing *Gryphæa, Trigonia, Lima,* and *Modiola.* The whole thickness of the zone cannot be less than forty-five feet."

Section V.—Rodborough Hill.

Although the beds composing the zone of *Ammonites Parkinsoni* have not the same thickness here as in the Cheltenham district, still their subdivisions may be readily distinguished, whilst many of the *Conchifera* are far superior in conservation to those found in the northern Cotteswolds. The rock having long been raised for road-material and boundary-walls, a considerable surface has in consequence been exposed. The beds are all extremely fossiliferous; and the shells, when it is possible to extract them from the hard matrix, are well preserved, although they are rarely got out entire.

	ft.	in.
A. *Upper Trigonia-grit.*—A hard, light-coloured sandy limestone, composed of several beds. There are two or more fossiliferous bands in the bed, crowded with *Conchifera.* The shells are in the condition of crystallized carbonate of lime, or represented by internal moulds	8	0
B. *Gryphite-grit.*—A greyish or brownish concretionary, siliceo-calcareous rock, filled with the valves of *Gryphæa sublobata* and a few other species of *Conchifera.* From 1 foot to	2	6
C. *The Lower Trigonia-grit.*—A hard greyish or brownish argillaceous limestone, crowded with the shells of *Conchifera* heaped together in all directions. The bed is in fact in great part composed of the valves of many species of *Mollusca,* and rests on a thick-bedded oolitic freestone, bored by *Annelida*	1	0

The above note having been made some years ago, I intended to have verified it now; but as I felt unequal at present to climb Rodborough Hill, I requested my esteemed friend, Dr. John Lycett, to examine the section for me; and he reports—

"I have been to Rodborough Fort today, Nov. 13, 1858, to take more exact observations on the bed with Gryphites; and the following is the result. Your account of the Trigonia-grit is sufficiently correct; and it is very remarkable how small at that place is the thickness of the rags between the Trigonia-grit and the Freestone or bored beds. At the eastern end of the quarries they are only two feet, and the separation into two beds is not very well defined; but towards the western side, that is, next to the Fort, it is clearly divided into two beds, which have an aggregate thickness of at least three feet. The upper portion is much harder than the lower, and is more siliceous, becoming at intervals concretionary, and abounding throughout its mass with the valves of Gryphites; in smaller numbers are other shells. As the bed is generally very hard, it is difficult to obtain anything like an accurate list of them; but I imagine there are on the whole a goodly list of *Testacea*, together with a few corals.

"The Gryphites are found in the basement-bed of the rags, almost down to the freestone. The prevailing character of the basement-bed is its argillaceous dark-grey colour; but there is much variability in its hardness and colour in its course through the long range of quarries. Upon the whole, I cannot see that the fossils of the Gryphite-stratum at this place can be dissociated from those of the crowded stratum next below; but I can quite understand that, where the rock has greater mass, the superposition of the fossils may be more distinctly marked, and that the Gryphite-bed may be more clearly separated from that beneath it. I fully remember that in a quarry upon the northern side of the valley, one and a half or two miles N.E. of Stroud, the *Gryphææ* occur in two distinct zones, with about three feet of rock between them."

Under the name "Pholadomya-grit," Dr. Lycett designates the uppermost beds of the upper Trigonia-grit, in which he has found the following species:—

Homomya gibbosa, *Sow.*
Pholadomya Heraulti, *Ag.*
—— Dewalquei, *Lyc.*
Ceromya plicata, *Sow.*
—— striata, *Sow.*
Terebratula globata, *Sow.*
Terebratula carinata, *Lamk.*
Rhynchonella angulata, *Sow.*
—— spinosa, *Schloth.*
Clypeus Plotii, *Klein.*
Holectypus depressus, *Lamk.*

Fossils of A. *Upper Trigonia-grit.*

Ammonites Parkinsoni, *Sow.*
—— Martinsii, *d'Orb.*
Trigonia costata, *Sow.*
—— V-costata, *Lyc.*
—— duplicata, *Sow.*
—— signata, *Ag.*
—— producta, *Lyc.* *
Opis similis, *Sow.*
Cardium Buckmani, *Lyc.*
Unicardium depressum, *Phil.*
Quenstedtia lævigata, *Phil.*
Macrodon Hirsonensis, *d'Arch.*
Trichites undulatus, *Lyc.*
Pecten demissus, *Phil.*

* This note on *Trigonia producta* has been kindly communicated by its author:—

Trigonia producta, Lycett.—The hard upper Trigonia-grit at Rodborough Hill has produced, rarely, an elongated *Trigonia* allied to *T. angulata*, Sow., but distinguished by the following characters:—It is much more produced and atte-

Pecten articulatus, *Schloth.*
Lima gibbosa, *Sow.*
—— bellula, *Lyc.*
Avicula digitata, *Deslong.*
—— ornata, *Goldf.*
Perna rugosa, *Goldf.*
Gervillia pernoides, *Deslong.*
Astarte subtrigona, *Goldf.*
—— rhomboidalis, *Phil.*
—— rugulosa, *Lyc.*
Ceromya striata, *Sow.*
Homomya gibbosa, *Sow.*
Pholadomya Heraulti, *Ag.*
—— media, *Ag.*
Pleuromya elongata, *Ag.*
Gresslya abducta? *Phil.*
Goniomya angulifera? *Sow.*
Terebratula globata, *Sow.*
—— carinata, *Lamk.*
Rhynchonella spinosa, *Schloth.*
—— angulata? *Sow.*
Clypeus Plotii, *Klein.*
—— Hugii, *Ag.*
Echinobrissus clunicularis, *Lhwyd.*
Holectypus depressus, *Lamk.*
—— hemisphæricus, *Desor.*
Pedina rotata, *Wright.*
Stomechinus intermedius, *Ag.*

Fossils of B. *Gryphite-grit.*

Gryphæa sublobata, *Desh.*
Pholadomya Heraulti, *Ag.*
—— media, *Ag.*
—— ovulum, *Ag.*
Trigonia striata, *Sow.*
Myopsis dilata, *Phil.*
Pleuromya Goldfussi, *Lyc.*
Lima compressa, *Wr.*, n. sp.
Pecten spathulatus, *Quenst.*
Goniomya angulifera, *Sow.*
Rhynchonella, sp.
Thecidium triangulare, *d'Orb.*

Fossils of C. *Lower Trigonia-grit.*

Ammonites Sowerbii, *Miller.*
Trochotoma carinata, *Lyc.*
Natica adducta, *Phil.*
Monodonta lævigata, *Sow.*
Turbo Etheridgii, *Lyc.*
Ostrea flabelloides, *Lamk.*
—— gregaria, *Sow.*
—— rugosa, *Goldf.*
Gryphæa sublobata, *Desh.*
Perna rugosa, *Goldf.*
Pecten lens, *Sow.*
—— demissus, *Phil.*
—— articulatus, *Schloth.*
—— personatus, *Goldf.*
Modiola plicata, *Sow.*
—— gibbosa, *Sow.*
Mytilus curtansatus, *Lyc.*
Mytilus tumidus, *Lyc.*
Pinna cuneata, *Phil.*
Trichites undulatus, *Lyc.*
Gervillia Hartmanni, *Goldf.*
—— tortuosa, *Phil.*
—— prælonga, *Lyc.* sp. n.
Lima proboscidea, *Sow.*
—— bellula, *Lyc. & Mor.*
—— gibbosa, *Sow.*
—— punctata, *Phil.*
Cucullæa oblonga, *Sow.*
Macrodon Hirsonensis, *d'Arch.*
Tancredia donaciformis, *Lyc.*
Quenstedtia oblita, *Mor. & Lyc.*
Corbicella compressiuscula, *Lyc.*
—— tumidula, *Lyc.*

B. The Parkinsoni-zone at Dundry has been already described (p. 24) in connexion with the Humphriesianus-beds, treated of in detail (p. 23).

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nuated posteriorly; the umbones are obtuse, not recurved; the anterior side is very convex and short, but rounded; the area is very narrow, flattened, nearly straight and smooth, traversed by an oblique mesial furrow, and sloping obliquely downwards; the marginal keel is distinct, but small, and nearly straight. The costæ are few in number (about eight), little elevated, but distinctly tuberculated throughout their course; their direction upon both sides is obliquely downwards, so that they meet at an obtuse angle near to the middle of the valve. The size of the costæ does not differ materially at their two extremities; therefore they do not form the elegant undulation seen in *T. angulata*, nor the acute angle of *T. V-costata.* A comparison of these features with the figure of the *T. angulata* given in the 'Mineral Conchology' will show that the latter shell has mesial recurved umbones, and an excavated posterior area; that the costæ do not form regular tubercles, and that they become large and prominent at their posterior undulation: altogether, Sowerby's species is a much more elegant shell.—J. L.

Near Bath, as at Widcombe Hill, the Inferior Oolite is represented chiefly by the upper subdivision of this formation. Not having examined this section, I cannot state whether the middle subdivision is likewise present; and unfortunately the determination of the species in Mr. Lonsdale's valuable memoir is not sufficiently precise to enable me to form an opinion thereon.

In the Yeovil district of Somerset, as I have already stated, the Humphriesianus-beds are overlain by light-coloured oolitic limestones, containing *Ammonites Parkinsoni*, and also shells characteristic of the upper subdivision of the Inferior Oolite, as shown in the section at Half-way House, to which the reader is referred (p. 35).

C. In the neighbourhood of Bridport, Dorset, the Parkinsoni-zone is well developed, and fully exposed in several instructive sections, as at Walditch Hill and Chideock Hill, near Bridport, and on the Down between Bridport Harbour and Burton Bradstock. The quarries on the hill were formerly worked for road-stone; but in consequence of the railroad having brought chalk-flints into the neighbourhood, the oolite has fallen into disuse. The following section represents, in descending order, the beds exposed near Burton Bradstock.

Section afforded by the Quarries in the Zone of Ammonites Parkinsoni *near Burton Bradstock.*

		ft.	in.
Zone of *Ammonites Parkinsoni.*	*a.* A coarse, ferruginous, ironshot oolite, containing many fossils: *Ammonites Parkinsoni, A. Truellei, A. subradiatus, Ancyloceras annulatum, Astarte obliqua*	3	0
	b. Thin-bedded oolitic limestone, with few fossils	1	6
	c. Brachiopoda-bed; a rich shelly oolite, containing immense numbers of *Terebratula sphæroidalis*	1	0
	d. Thin-bedded oolitic limestone; few fossils.	1	8
	e. Coarse brown oolitic limestone	2	0

Fossils from the Burton Bradstock Quarries (Parkinsoni-zone).

Ammonites Parkinsoni, *Sow.*
—— Martinsii, *d'Orb.*
—— Truellei, *d'Orb.*
—— subradiatus, *Sow.*
Nautilus lineatus, *Sow.*
Belemnites giganteus, *Schloth.*
—— canaliculatus, *Schloth.*
Pleurotomaria Proteus, *Deslong.*
Purpurina ornata, *Sow.*
Astarte obliqua, *Lamk.*
—— subtrigona, *Münst.*
Modiola cuneata, *Sow.*
Lima semicircularis, *Goldf.*
—— proboscidea, *Sow.*
Pholadomya Heraulti, *Ag.*
Pleuromya Jurassi, *Brong.*
Rhynchonella spinosa, *Schloth.*
—— plicatella, *Sow.*
Terebratula sphæroidalis, *Sow.*
—— Phillipsii, *Mor.*
Clypeus Agassizii, *Wr.*
—— altus, *M'Coy.*
Hyboclypus gibberulus, *Ag.*
Stomechinus bigranularis, *Lamk.*
Cidaris Bouchardii, *Wr.*
Holectypus hemisphæricus, *Desor.*
Collyrites ringens, *Desm.*
—— ovalis, *Leske.*
Montlivaltia trochoides, *Edw. & Haime.*
—— Delabechei, *Edw. & Haime.*
Trochocyathus Magnevillianus, *Michel.*
Discocyathus Eudesi, *Michel.*

§ IV.—*Conclusion.*

In the preceding pages I have (in the first place) endeavoured to show that we find the true equivalents of the Upper Lias Sands and Cephalopoda-bed of the South of England in the Yorkshire coast; for, although the lithological features of this formation are somewhat different in the north, still its palæontological characters leave no doubt as to the correlation of the Blue Wick beds near the Peak with the Cephalopoda-beds of Gloucestershire.

2nd. The chief object of this memoir was to demonstrate that the Inferior Oolite admits of a subdivision into three zones of life, and that each of these is characterized by certain species of *Mollusca, Echinodermata,* and *Anthozoa,* which are special to it.

3rd. That the zones are unequally developed in different regions in England; and the same remark applies to France and Germany. The individual beds composing these subdivisions are sometimes thin and feebly shown, or altogether absent in some localities, and are more or less developed in others. The zone of *Ammonites Murchisonæ* is the one most frequently absent; that of *Ammonites Humphriesianus* has a wider geographical area; whilst the zone of *Ammonites Parkinsoni* is the most persistent, and is frequently the only representative of the Inferior Oolite formation.

4th. That several *Conchifera* and a few *Gasteropoda* are common to the three zones, whilst most of the *Cephalopoda, Brachiopoda, Echinodermata, Anthozoa,* and *Polyzoa* lived only in one of these subdivisions; and that each zone contains a fauna of its own, which sufficiently characterizes it.

5th. That the zone of *Ammonites Parkinsoni* possesses many species of *Mollusca, Echinodermata,* and Corals in common with the Cornbrash; and the zone of *Ammonites Murchisonæ,* several *Conchifera* which lived in the Jurensis-stage of the Upper Lias; whilst the *Cephalopoda, Brachiopoda, Echinodermata,* and Corals of the Inferior Oolite are all specifically distinct from those of the latter formation.

6th. The existence of three different faunas in the Inferior Oolite is evidence that a long period of time elapsed during the accumulation of this formation; and the successive appearance and extinction of so many different forms of *Invertebrata* testifies that many important changes of level in the bottom, as well as in the shore-line of the Jurassic sea, had taken place during the deposition of the oldest member of the Lower Oolitic rocks.

April 20, 1859.

Robert Folkestone Williams, Esq., 76 Coleshill Street, Eaton Square, and Phillip Debell Tucker, Esq., 36 Holford Square, were elected Fellows.

The following communications were read:—

1. *On some* Reptilian Fossils *from* South Africa. By Professor Owen, F.R.S., F.G.S., &c.

(Plates I. II. III.)

Genus Dicynodon: Subgenus Ptychognathus*, Ow.

This subgenus is founded on four skulls, forming part of the collection transmitted to the British Museum in 1858, by His Excellency Governor Sir George Grey, K.C.B., from the sandstone rocks at the foot of the Rhenosterberg, S. Africa. These skulls belong, by their dentition, to the Dicynodont family, but present such strongly marked deviations from the type species of the genus (*Dicynodon lacerticeps*, Ow.) as to indicate a distinct subgeneric section; they were accordingly entered in the Museum list, and labelled in the cabinet where they are exposed to view, under the term *Ptychognathus*.

Dicynodon (*Ptychognathus*) *declivis*, Ow. (Plate I. figs. 3, 4, 5.)

In this species, assuming the horizontality of the upper (fronto-parietal) plane of the cranium (Pl. I. fig. 3 11) as giving the natural position of the skull, the broad plane of the occiput meets the fronto-parietal plane at an acute angle, rising from the condyle upwards and backwards—a direction not hitherto observed in any reptile, and similar to that presented by the occiput in relation to the vertex in the feline and many other gyrencephalous mammals.

The fronto-parietal plane (ib. fig. 5) is bounded by an anterior ridge, 14, 15, extending from one superorbital process to the other, with a gentle convexity forward, including the interorbital space. From this ridge the facial part of the skull (fig. 3 15, 22) descends in a straight line in a direction nearly parallel with that of the occiput, but slightly diverging from that parallel as it extends downward and forward. The occipital ridge (fig. 4 7, 8) is much produced, and is deeply notched at the middle, the sides of the notch being continued forward and gradually subsiding on the parietal plane as they curve outward to the postfrontals (fig. 5). In the middle of the fronto-parietal surface is a transverse pair of tubercles. The occipital plane, owing to the outward expansion of the masto-tympanic plates (fig. 4 8, 28), becomes the broadest part of the skull, which quickly contracts forward to the ridged beginnings of the alveoli of the canine tusks (fig. 5 21).

* From πτὺξ (gen. πτυχὸς), a fold, and γνάθος, a jaw.

The nostrils (*n*), divided by a broad and almost flat base of the premaxillary (figs. 3 and 5 22), are situated, as in *Enaliosauria*, much nearer the orbits than the muzzle. They are proportionally smaller than in the typical Dicynodonts.

The orbits (*o*) are oblong and have a somewhat reniform figure, owing to the production of the superorbital ridge into a protuberance a little behind its middle part; their posterior boundary describes a strong convex curve between this protuberance and the zygomatic arch. The form of the orbit suggests that the reptile had the power of turning the eye-ball so as to look upward and backward, as well as outward, in a peculiar degree. The cranium has undergone no pressure or distortion to produce this form of orbit. The upper outlets of the temporal fossæ (fig. 5 8) are broader than they are long, and wider externally than internally. The palate has a single large oval vacuity at its back part, bounded externally and behind by palato-pterygoid ridges.

In one orbit a few of the sclerotic plates (fig. 3 *s*.) were preserved.

The occipital condyle is subtrilobate, and is formed by the basi- (fig. 4 1) and ex-occipitals (ib. 2) in pretty equal proportions. After most careful scrutiny on removal of the matrix from the surface of the fossil bone, I believe the exoccipitals to have coalesced, or to have been connate, with the paroccipitals, analogous to the confluence of the ex- and par-occipitals in the Crocodiles*. The exoccipitals (ib. 2) meet and join together above the foramen magnum. The broad occipital plate or "bone" so formed is emarginate above for the superoccipital (ib. 3); and the outer boundary or suture describes a strongly undulating course as it curves outward and downward to the paroccipitals. These processes (ib. 4), abutting against the lower part of the mastoids, are divided by a notch from the hypapophyses (*h*) of the basioccipital, which are thicker in proportion to their length than in the *Dicynodon tigriceps*. The outer surface of the occiput, so defined, is undulating; but much of the occipital plane at its upper and lateral parts is contributed by the parietals (7) and mastoids (8), especially the latter, which are of great extent. The parieto-mastoid suture runs upward to the middle of the back wall of the upper outlet of the "temporal" fossa. The mastoids unite with the exoccipitals by a deeply indented suture: a ridge is developed where the masto-tympanic joins the paroccipital. About an inch external to the parieto-mastoid suture the mastoid developes a strong subvertical ridge, which extends forward to meet the postfrontal and malar, and to form the zygomatic outer boundary of the temporal fossa. Between the zygomatic and occipital plates of the mastoid, that bone is deeply and widely excavated externally. Between the top of the superoccipital and the parietal I cannot discern a suture; and it is by analogy that I regard the lower median portion of the symmetrical two-lobed bone (fig. 4 3) which enters the upper notch of the coalesced exoccipitals as the superoccipital. The lobes are formed by the convex parietal ridges which are continued forward

* Geol. Trans. 2nd ser. vol. vii. p. 241, pl. xxxiii.

upon the upper surface of the cranium (fig. 5), quickly subsiding to form the inner boundary of the temporal fossæ, and finally curving outward to the back part of the orbits. There is no trace of median suture between the parietals; these form one bone, perforated by a small "foramen parietale" close to the coronal suture. The frontals (11) are broader than they are long, and contribute a small share to the superorbital border. Anterior to the two tuberosities of the vertex the median suture between the frontals is distinct; and the suture is continued forward, between the nasals (15), beyond the anterior transverse ridge upon the straight sloping part of the skull, for nearly an inch, where the nasals join the premaxillary bone. The superorbital prominence is developed by a large subtriangular "prefrontal" (14), the outer surface of which is divided into a horizontal facet and a sloping facet by the outer parts of the anterior transverse cranial ridge. The lacrymal (73) forms the fore part of the orbit, extending nearly half an inch forward upon the face; the outer surface of the premaxillary (fig. 5 22) is traversed by a low median ridge dividing the upper, nearly flat, elongated surface of the bone. The sides of the premaxillary (fig. 3 22) bend abruptly down in front of the nostrils, at a slightly open angle with the upper surface, to join the maxillaries about 8 lines below the angular bend. The maxillaries (ib. 21) form the lower boundary of the nostrils, and join above and behind with the prefrontal, lacrymal, and nasal bones: their outer surface is divided by the strong ridge which has suggested the subgeneric name for the fossil. This ridge, commencing below the orbit, where it seems to be a forward continuation of the zygoma, becomes more prominent as it extends forward, and soon forms the outer angle of the three-sided socket of the canine tusk. One side of this socket is formed by the upper and outwardly concave surface of the maxillary, a second side by the lower and equally concave surface, and the third side by the inner and inwardly convex nasal plate of the maxillary. The sockets diverge as they descend, with a slight curve, convex outwards. The lower jaw is edentulous; it is deep and broad in proportion to its length; it is composed according to the type of the mandible in the Dicynodons proper, but with the fore part of the broad symphysis more produced and bent upward, like the fore part of the lower mandible in some Parrots.

For the species indicated by the above-described cranium I have proposed the name of *Ptychognathus declivis*.

Ptychognathus latirostris, Ow.

A second species of *Ptychognathus* is indicated by a skull which in in its facial part is broader and shorter, and which has the orbits of a more circular form, yet presenting the notch at the upper and back part. The sloping facial part of the skull presents the same straight outline, and is of the same length, viz. 4 inches, as in *Pt. declivis*; but its breadth at the base of the canine sockets is 3 inches 2 lines, beyond which they slightly expand; and the ridges of these sockets begin to project nearer to the orbits.

The zygomatic arch is a deep compressed plate of bone, with a convex upper border inclining a little outward, formed chiefly by the mastoids, which join the squamosal and malar near the lower and back part of the orbit,—the squamosal there being wedged between the mastoid and malar, forming the infero-anterior boundary of the temporal fossa. Between the zygomatic and tympanic plates a wide and deep oblique channel is included, which expands as it extends obliquely downward and forward.

The prefrontals, as in *Pt. declivis*, develope the superorbital tuberosities and the outer part of the ridge dividing the upper from the fore part of the cranium. The postfrontals form the hinder boundary of the orbits. The frontals contribute a small part to the upper boundary. The lacrymal forms the infero-anterior boundary, and extends a short way upon the face. A bone below the nostril appears in the present skull to be marked out by a fissure on each side from the maxillary; it may be a dismemberment of the lacrymal. The nasals are a pair of broad bones, each of a rhomboidal shape; they form the middle part of the anterior cranial ridge, behind which they unite with the frontals and prefrontals: their lower and front borders diverge to receive the upper part of the long premaxillary, and to form the upper boundary of the nostrils. Each nasal, in advance of the precranial ridge, presents two facets, the outer one bending down to join the facial part of the prefrontal.

The superior maxillary presents a deep facial plate, proportionally deeper behind than in *Pt. declivis*: its postero-inferior part is produced into a slender pointed process, underlapping and on the inner side of the malar, below the orbit: in advance of this, the bone rapidly expands, a ridge dividing the outer from the under part of the bone: this is not continued directly into the alveolar ridge, the latter beginning to rise a little above the termination of the former ridge. Below this termination and the beginning of the alveolar ridge, the maxillary sends down an inequilateral triangular plate to join the palato-pterygoid boundary of the palatal nostril. Above this plate the maxillary expands to form the socket of the canine tusk, which is strengthened by the strong ridge on its outer part. The upper part of the maxillary forms the lower half, or more, of the side of the face, and terminates anteriorly above the alveolus, by forming a small part of the alveolar border. This border, anterior to the tusk, is continued obliquely upward and forward to the middle of the premaxillary bone—a peculiarity of contour which demands a corresponding production of the fore part of the mandible to close the mouth.

The premaxillary is a long single bone; if it were ever divided at the middle line, the suture has been obliterated: the bone has all the appearance of having been single, as in Birds and most Lizards. It is of unusual length: beginning above by the pointed termination wedged between the nasals, it expands to the fore part of the nostrils, the sides of the bone there beginning to bend down at an open angle (nearly approaching a right one) with the upper surface; this surface maintains almost the same breadth to the alveolar border: it is

traversed along its middle by a low ridge: the sides of the premaxillary, in the present species, increase a little in depth as they approach the alveolar border. This border, in front of the canine, forms an open angle with the part of the border behind the canine, the one passing into the other with a convex curve on the inner side of the socket of that tooth.

The rami of the lower jaw augment in depth from the angle to the symphysis, where they meet at an acute angle and are confluent. The angle projects a very little way beyond the articulation; it is continued inward a short way, and is slightly bent down. The articular surface is moderately concave, and looks obliquely upward and backward. The elements of the posterior half of the ramus, answering to the articular, angular, and surangular in lizards, are too closely compacted together in the specimens under examination to permit an exact definition of their limits. A thin vertical "splenial" plate, on the inner side of the ramus, begins about an inch in advance of the angle, and extends forward to the symphysis, at the back part of which it appears to become confluent with its fellow. The part answering to the "angular" diverges from the surangular, and forms the hind boundary of an oblong vacuity at the middle of the side of the ramus, the fore part of which vacuity is formed by a bifurcation of the dentary element: the fore part of the angular piece is continued forward between the lower branch of the dentary and the splenial to the symphysis, where it penetrates a fissure either in the dentary or between the dentary and splenial: it forms the lower boundary of the vacuity at the middle of the ramus. The upper boundary is formed by the upper branch of the dentary, which overlaps the fore part of the surangular. The dentary is thickened and strengthened by a ridge or rounded rising, continued forward from the upper boundary of the fissure, and subsiding at the vertical channel upon the side of the symphysis, receiving the tusks when the mouth is closed. The symphysis of the mandible (fig. 3 $_{32}$) in both species of *Ptychognathus* is peculiarly massive—broad, high, and thick. Anteriorly it is convex in every direction; it is bent or produced upward, terminating in a broad, convex, subtrenchant or trenchant margin, and resembles the fore part of the lower mandible of a Maccaw. The upward development of the fore end of the lower jaw is necessitated by the oblique truncation of the premaxillary,—the mouth here opening obliquely upward, as in some Fishes, giving a very odd physiognomy to the skull of *Ptychognathus*.

The modification of the back part of the head of *Ptychognathus*, especially the great expansion due exclusively to the development of ridges for augmenting the surface of attachment of muscles (for the brain of the cold-blooded reptile would need but a small spot of the centre of the occipital plates for its protection), indicates the power that was brought to bear upon the head as the framework in which were strongly fixed the two large tusks. The power of resistance of the cavities receiving the deeply implanted bases of the tusks was increased by the ridges developed from the outer part of their bony wall.

Ptychognathus verticalis, Ow. (Pl. I fig. 2.)

The skull upon which this species is founded is about half the size of the foregoing, from which it differs in the more vertical position both of the occiput, the canines and their sockets, and the premaxillary part of the skull.

The orbits, relatively larger than in the foregoing species (which may be, however, an immature character), are oval in form, as in *Pt. declivis*; but the long axis is in the opposite direction, viz. from above downward and backward.

The hind boundary of the orbit, formed by the postfrontal, curves forward at its lower part to join the malar, leaving an entering angle between it and the zygomatic part of the malar. The composition of the cranium and lower jaw accords with that of the preceding species. In the relative breadth of the almost flat interorbital platform, the abrupt down-bending of the face, the small size of the nostrils, the ridged canine sockets, and the general angularity of the profile of the skull, the present species repeats the subgeneric characters of the two foregoing kinds of *Ptychognathus*; and they are well-marked in comparison with those species of *Dicynodon* proper (viz. *D. testudiceps* and *D. strigiceps*) which most resemble the *Ptychognathus verticalis* in the relative position and direction of the tusks. A vertical transverse section taken across the base of these tusks shows their wide pulp-cavity at that part; the thin inner wall of their alveoli encroaching upon the nasal cavity; the thin septum narium bifurcating below; the absence of all trace of successional teeth where in such sections their germ is commonly seen in other Saurians; and the great thickness of the undivided facial part of the premaxillary, forming the roof of the nasal passages. The bony palate is entire from the premaxillary border to a little beyond the sockets of the tusks: it presents the pair of short anterior ridges and the longer and more prominent median ridge behind these, answering to those in the palate of *Dicynodon testudiceps*.

Genus Oudenodon*, Bain.

Mr. Andrew G. Bain, the discoverer of the bidental Reptiles of South Africa, in a letter published in 'The Eastern Province Monthly Magazine' (p. 10), Graham's Town, September 1856, thus notices another form of fossil Reptile occurring in formations of the same age, near Fort Beaufort:—"There were many skulls entirely without teeth, which we at first thought had belonged to the Chelonians or Turtles; but afterwards, finding that the animals had distinct narrow ribs, which Chelonians have not, we put them down also for something new, and named them 'Oudenodons,' or toothless animals."

Of this genus, Mr. Bain's collection, now transferred to the British Museum, contains cranial evidences of two distinct species; and a third species is represented by an entire but somewhat crushed cranium and lower jaw, in the collection transmitted in 1858 to the British Museum by Governor Sir George Grey, G.C.B.

* From οὐδεὶς, none, and ὀδοὺς, a tooth.

Oudenodon Bainii, Ow. (Pl. I. fig. 1.)

In this species the back part of the skull, greatly extended in breadth by the expanse of the lamelliform sinuous masto-tympanics, inclines from above the occipital condyle upward and forward, the superoccipital being continued into the parietal by a longitudinal channel between the occipito-temporal cristæ, where the back part passes into the upper part of the cranium.

The temporal fossæ are longer than they are broad, and are relatively much longer and narrower than in the *Ptychognathus*; in this respect *Oudenodon* more resembles *Dicynodon*: a relatively wider space is left between the temporal ridges at the upper or parietal region of the cranium. The zygoma is a long, rather slender, compressed bar, with its upper border directly obliquely upward and outward, its inner side obliquely upward and inward. The postfrontal bar dividing the temporal fossa from the orbit is directed from within outward, backward and slightly downward. The interorbital space is narrower than the intertemporal one, so that the lower border of the orbit has a more outward position than the upper one, and the aspect of the orbits is very oblique, rather more upward than outward. The profile of the face descends by a regular curve from the upper to the fore part, which is nearly vertical,—the premaxillary being continued more nearly to the level of the alveolar border of the maxillary than in *Ptychognathus*. There is a low tubercle upon the prefrontal part of the orbital border; and a somewhat larger tubercle projects above the nostril. This cavity is relatively larger than in *Ptychognathus declivis*; and both premaxillary and maxillary are more deeply notched to form its fore and under boundary: the nasal, prefrontal, and lacrymal complete that boundary. Below the middle of the orbit a thick, smoothly rounded, vertical ridge projects from the maxillary, in the position of the alveolus of the tusk in *Pt. verticalis*; but it rather suddenly subsides upon the alveolar border, which is here entire and imperforate, forming simply a low obtuse angular projection upon that border. Sections of fragments of *Oudenodon* have demonstrated this ridged part of the maxillary to be solid, without the vestige of a germ of a tooth answering to the tusk in Dicynodonts. The rest of the alveolar border, chiefly formed by the premaxillary, is toothless and subtrenchant, as in the Dicynodont reptiles; and, the lower jaw presenting the same structure, we have in the present remarkable reptile an edentulous Saurian, as is the *Rhynchosaurus* of the New Red Sandstone of Shropshire.

The composition of the skull is essentially the same in *Oudenodon* as in *Dicynodon*; and the same affinities may be predicated of it, with such additional approach to Chelonia as the total absence of teeth may indicate. But the double nostril and well-ossified occiput demonstrate the more essential Saurian affinities of the genus.

Oudenodon prognathus, Ow.

As the former species of *Oudenodon* resembled the typical *Dicynodon* in the shortness of the face and curvature of its contour, so the

present species resembles the *Ptychognathus* in the length of the face, and more especially the *Pt. declivis* and *Pt. latirostris* in its direction and in the relative position of the ridge representing the canine's socket to the nostril. In *Oudenodon Bainii* this ridge is behind the nostril; in the present species it is beneath it, and is more horizontal than vertical.

The orbits have the same oblique aspect, upward and outward, as in *Oud. Bainii*, but their longitudinal exceeds their vertical diameter; the nostrils have a similar longitudinally oval shape, and are more directly in advance of the orbit; the supernarial tuberosity is relatively larger. The maxillary ridge is more angular and more produced, besides being continued more obliquely forward. The correspondingly produced and sloping part of the premaxillary is nearly straight, and is strengthened, as in *Ptychognathus*, by a low median obtuse ridge. The maxillary ridge subsides below, to the edentulous alveolar border, rather more gradually than in *Oudenodon Bainii*, its outer longitudinal contour forming a gentle convex curve; these ridges give a very peculiar feature to the present skull. The fore part of the premaxillary does not descend so nearly to the level of the maxillary alveolar process as in the *Oudenodon Bainii*, and consequently the symphysis of the mandible is more produced and curved upward, which is another feature of resemblance to *Ptychognathus* in the present skull,—the depth of the symphysis here exceeding the same diameter of the opposed fore part of the upper jaw. The symphysis is narrower in proportion to its length than in *Ptychognathus*; its fore part is slightly produced along the middle line, resembling a low ridge. The vacuity between the dentary and angular elements is long and narrow; it is overarched by a slight ridge.

Oudenodon Greyii, Ow.

A third species of *Oudenodon*, with maxillary ridges as in *O. prognathus*, has a less elongated cranium and temporal fossæ, more rounded orbits, and a narrower interorbital space. It forms part of the collection transmitted by Sir George Grey, to whom the species which it indicates is dedicated.

Hyoid apparatus of Oudenodon. (Pl. III. fig. 5.)

In an obliquely crushed specimen of the skull with the lower jaw of the *Oudenodon Greyii* there are several bones, constituting a symmetrical apparatus in the position of the hyoid, beneath and between the rami of the lower jaw, where they are evidently in advance and rather to one side of their proper position. The hindmost, on the middle line (fig. 5 43), is best preserved. It is broad, flat, and very thin, of a symmetrical semicircular form, with a production like a stem from the middle of the straight side, which is directed forward. This stem is partly underlapped by the median end of a pair of long, narrow, flattened bones (ib. 45), which proceed transversely outward, slightly expanding to that end. Their anterior border is straight, the posterior border is slightly concave.

To the outer end of each of these bones seems to have been connected or articulated a long slender bone (ib. 46), with a slight sigmoid curve, directed backward. The following appear to be the homologies of the foregoing bones. The median and most posterior of them is the uro-hyal, no. 43. The transverse pair answer to the hindmost pair, *a a*, in the hyoid of the Tortoise, figured by Cuvier* in the 'Ossemens Fossiles,' 4to, tom. v. pt. ii. pl. 12. fig. 42 (my "basibranchial," no. 45). The longitudinal pair appended to them answer to *c c* in the same figure (my "hypobranchials," no. 46†).

In advance of the left basibranchial is a flattened broad lamelliform bone with the fore and hind borders convex, the outer and inner ones concave; but the median or inner border of this plate is not entire. The bone in question may be either a median symmetrical piece, like the uro-hyal, but displaced; or it may be the left of a pair of plates, answering in that case to the middle pair, *a a*, in the above-cited figure of the hyoid of the tortoise. I incline to the latter opinion, and believe it to be the half of a basi-hyal, no. 41, divided in the median line.

To the outer concavity of this bone has been attached the end of a long and strong bone, flattened and gradually expanded at both ends; it is directed outward and backward. It is a large and strong cerato-hyal, no. 40, and is double the length of the hypobranchial or posterior "cornu."

The lower jaw in the skull, showing the above-described hyoid apparatus, is $4\frac{1}{2}$ inches long. The length of the cerato-hyal is $3\frac{1}{2}$ inches: that of the hypobranchial is $2\frac{1}{4}$ inches. The length of the uro-hyal, 4, is 1 inch; its breadth is nearly the same.

At the fore part of this lower jaw the intercalation of the fore end of the angular element (31) between the splenial (32) and dentary (33) is well shown.

In the Crocodilians there is a broad cartilaginous basi-hyal suspended by a pair of strong bony cerato-hyals; but there are no distinct thyro-hyals (hypobranchials), nor any uro-hyals.

In Lacertians there are both cerato- and thyro-hyals; and in some genera of Iguanians and Lizards proper (*Lacerta*, Cuv.) there is a long and slender bifurcated uro-hyal or pair of uro-hyals. The thyro-hyals are not supported on distinct bones, answering to the basibranchials, 45.

In Chelonians the uro-hyal is wanting; but in some species (*Testudo elephantopus*) the thyro-hyals or hypobranchials are articulated to a pair of bones answering to the basibranchials in Fishes, which diverge from each other to form those articulations.

In *Oudenodon*, and probably also in *Dicynodon*, the type of the hyoid apparatus conforms most with that in the *Chelonia*, but combines therewith certain Lacertian characters.

In the composition and general form of the skull *Oudenodon* so closely resembles *Dicynodon* and *Ptychognathus* as to indicate a general family relationship. Viewing, indeed, the ridged indication

* Archetype of the Vertebrate Skeleton, 8vo. p. 68. † Ib. p. 71.

of the sockets of the pair of upper canines in *Oudenodon* (Pl. I. fig. 1 21), the surmise is suggested whether the species of this genus may not originally have possessed tusks, which after being shed had not been replaced, leaving the cavity of the sockets to absorption and obliteration. Or it might be asked whether the Oudenodons may not be the females of Dicynodons, in which, as in the Narwhal, rudimental tusks may have been originally hidden in the substance of the ridged tracts of the upper jaw, and afterwards absorbed. Hitherto, however, I have not met with species of *Dicynodon* or *Ptychognathus* sufficiently resembling any *Oudenodon* in cranial characters to support their ascription to the same species with merely the sexual difference in respect to tusks.

The following are admeasurements of some of the skulls of the Dicynodont Reptiles above described:—

	Oudenodon			*Ptychognathus*		
	Bainii.	*prognathus.*	*Greyi.*	*declivis.*	*latirostris.*	*verticalis.*
	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.	in. lin.
Length of skull	6 5	......	......	8 0	8 6	5 0
Breadth of occiput	5 6	......	......	6 4	6 8	3 6
——— intertemporal space	1 2	1 2	0 10	1 2	1 7	0 11
——— interorbital space	0 11	1 1	0 9	2 8	3 0	1 10
——— between the superorbital protuberances	1 6	1 10	1 3	3 6	4 0	2 6
——— skull anterior to the orbits	2 8	2 10	......	3 10	3 6	2 8
——— across middle of alveoli of tusks	......	......	......	2 8	3 4	2 3
——— internasal space	0 9	0 9	0 8	1 3	1 7	0 10
——— each temporal fossa	1 4	......	......	2 6	2 6	1 9
Length of each temporal fossa	2 6	......	......	2 3	2 3	1 9
From hindmost part of skull to the orbit	3 10	......	......	2 4	2 7	2 3
——— forepart of orbit to the forepart of premaxillary	2 3	2 8	2 4	3 9	4 0	2 3
Long diameter of orbit	1 8	1 9	......	2 2	1 7	1 6
——— nostril	0 11	0 8	......	0 11	0 8	0 6
Greatest breadth of bony palate	1 6	......	......	1 5	1 8	0 0

Genus Galesaurus, Ow.*

Galesaurus planiceps, Ow. (Pl. II.)

The shape of the skull on which the above genus and species are founded is that of a narrow spade on playing-cards, the occipital condyle forming the handle: it measures $3\frac{1}{2}$ inches in length and 2 inches 9 lines in extreme breadth across the zygomatic arches; but its greatest depth, including the lower jaw, does not exceed an inch; and this diameter varies very little, the upper surface of the skull being unusually flat and level.

* From γαλῆ, a weasel, and σαῦρος, a lizard.

The occipital plane is singularly inclined from below upward and forward, and that of the occipital foramen (fig. 3 *f*) partakes of the same inclination, the condyle (figs. 2 & 3 *g*) being much produced behind and beyond the upper border of the foramen. The shape of the occipital surface, which is completely or continuously ossified, is triangular, bounded laterally by a pair of strongly developed sharp ridges, converging upward and forming the boundary between the occipital (2, 3) and temporal (*t*) fossæ. The occipital surface may be called a "fossa" from its concavity; but the surface is undulated by a median and two lateral slight convexities along lines radiating from the foramen magnum.

The parietal crest (fig. 3 7), advancing from the angular summit of the occipital ridge, bifurcates to surround an elliptical "foramen parietale;" and the divisions thence gradually diverge to the post-frontal (12). The tympanic (28) is a broad deep plate of bone, convex outwardly; it extends outward and forward from the lower part of the occipital ridge, formed by the mastoid (8) and paroccipital (4).

The zygomatic arch is continued forward from the tympanic (fig. 1 28), a little decreasing in depth, to the postorbital boundary (26). The temporal fossa (fig. 3 *t*) is very wide, and is of a rhomboidal figure, the antero-lateral boundary being parallel with the occipital ridge, and the postero-lateral boundary being parallel with the internal or cranial boundary. The long diameter of the fossa is 1 inch 3 lines; its short diameter is 1 inch; from the front to the hind angle the fossa measures 1 inch 6 lines; the breadth of the cranium between the fossæ is 6 lines.

The orbits are of a subtriangular form, with the corners rounded off: their aspect is more upward than outward: their long diameter is 6 lines: the breadth of the upper interorbital space is 9 lines. The suture between the frontals and nasals is parallel with the fore part of the orbits. The post- (12) and pre- (14) frontals unite above the orbit, and contribute a narrow tract to each side of the interorbital space: this space is flat. The nasals are flat: the rounded angles by which the upper surface passes into the vertical side-surface of the facial part of the skull are formed by the maxillaries. The nostril (figs. 1 & 2 *n*), is single, terminal, and vertical; it is bounded laterally by short premaxillaries.

The most interesting peculiarity in the skull is the well-marked definition from the other teeth, by a contrasted superiority of size, of an upper and lower canine tooth on each side, having the same position in the skull and relative position to each other as in the carnivorous mammals. In no other Saurian are incisors so divided from molars by a single canine; in none is such definition of the three kinds of teeth so plain and unequivocal.

The premaxillaries contain each four equal-sized teeth with simple conical crowns, 2 lines in length, sloping a little forward from the vertical position, and passing in front of the lower incisors when the mouth is shut. The eight lower incisors are narrower, but have about the same length of crown. Both upper and lower incisors are arranged in contact, or close order, as in Mammals.

The lower canine (figs. 1 & 2 *c'*) is subcompressed, very slightly recurved, 9 lines in length, 2 lines in breadth. The projecting crown is $5\frac{1}{2}$ lines long; the implanted base is $3\frac{1}{2}$ lines long: this extends very close to the lower margin of the mandible and becomes a little contracted there, but shows a short conical pulp-cavity, without any trace of the germ of a successor. It closely resembles the completely formed canine of a mammalian carnivore, in shape, structure, implantation, and direction.

The upper canine (ib. *c*) is larger; two-thirds of the tooth are preserved on the right side (fig. 2); the inner wall of the socket is shown on the left side (fig. 1 *c*). In shape this tooth resembles the lower canine: its greatest breadth is nearly 3 lines, its length seems not to have been less than 11 lines: it crossed the lower canines obliquely, its socket being more backward and outward in position; and while the points of the lower canines a little diverged from each other, those of the upper ones slightly converged. The socket of the upper canine extends close to the upper surface of the skull, and even causes a slight prominence on that part of the maxillary, close to its suture with the nasal. The depth of the implanted part of the upper canine is 7 lines. There is no trace of a recess for a successional tooth at the base of the inner wall of the socket (*c*, fig. 1).

Twelve close-set, conical, subcompressed teeth succeed the lower canine, their protruded crowns becoming shorter, and their implanted bases longer, as they recede in position. A thin layer of bone immediately surrounding the simple base of each molar tooth has a brick-red colour, as if retaining a stain from the hematosine of the vascular alveolar lining membrane; the exposed socket of the upper canine presents the same colour; the other parts of the fossil bone are grey.

The upper molars passed external to the lower ones when the mouth was shut. The "symphysis mandibulæ" is very short. The rami diverge from the linear trace of junction, at an acute angle, straight to the articular end. The length of each ramus from the lower and back part of the symphysis is 2 inches 8 lines. The receding "mentum" is 6 lines long: the depth of the ramus below the first molar is $4\frac{1}{2}$ lines; it gradually increases to 6 lines below the last molar.

There is a series of small vascular foramina above the alveolar border of the upper jaw; and indications of the same saurian character are discernible in parts of the lower jaw.

The reptilian nature of the above-described skull is shown by its single occipital condyle, and by the complex "frontal bone"; its crocodilian affinities by its terminal single nostril. The more generalized saurian character is exemplified by the large temporal fossæ and the "foramen parietale"; whilst a most singular and suggestive approach to the mammalian class is made in the above-described characters of the dentition.

The predominance of the canines, their seeming want of successors—the certain absence, at least, of such evidence as would have appeared had the canines been subject to the ordinary law of saurian dentition—point to at least an analogical relationship with the Dicynodonts;

the structure of the occipital region of the skull also conforms to the type of those singular South African reptiles. The breadth and flatness of the skull and the proportions of the orbits and temporal fossæ recall the proportions of *Simosaurus* amongst the peculiar saurians of the triassic deposits of Germany.

The original (from the Rhenosterberg) was transmitted to the British Museum by Governor Sir George Grey, K.C.B.

Genus Cynochampsa*, Ow.

Cynochampsa laniarius, Ow. (Pl. III. figs. 1–4.)

This genus and species are indicated by the extremity of the upper and lower jaws (figured in Pl. III. figs. 1-4), from the same locality as *Galesaurus*, and forming part of the same collection transmitted by Governor Sir George Grey, K.C.B. Sufficient of the jaw is preserved to show that it must have terminated in a more or less produced narrow muzzle, which, including the under jaw, would present a subcylindrical transverse section, as in the Gavial and Teleosaur: but a close-set series of small and similarly sized incisor teeth are separated from the rest of the dentition by a pair of upper and a pair of lower canines, as well contrasted by their superiority of size as in *Galesaurus*. Instead, however, of these canines being immediately followed by small molar teeth, there was a toothless space extending at least as far as the upper jaw has been preserved on the fossil under description; and this space equals at least twice the breadth of the crown of the upper canine.

The upper incisors are ten in number (five in each premaxillary bone), conical, with a subcylindrical base. The lower incisors, of similar size and shape, appear to have been eight in number. Both upper incisors and canines overlapped those teeth in the lower jaw when the mouth was shut. The crowns of the upper canines and the implanted roots of the lower ones have been broken across, exposing the pulp-cavity, as is shown in looking upon the fossil from below, as in fig. 4 *c*, *c'*; and the lower canines are a little in advance of the upper ones. The relative positions of the incisors and canines were nearly the same as in *Galecynus*; the crowns of the lower canines were perhaps more completely concealed when the mouth was shut. The nostril is single, terminal, of a transversely oval shape, with the plane of its outlet inclined from above downward and forward. The aperture is bounded by the premaxillaries (fig. 3 $_{22}$) below and at the sides, and by the nasals (ib. $_{15}$) above. The extremity of the upper jaw, pierced by the nostril, is slightly expanded, as in the Teleosaur, but in a less degree than in the Gavial.

In a collection of fossil remains from the Drakenberg Mountain, near Harrismith, Cape of Good Hope, transmitted in 1854 by Joseph Millard Orpen, Esq., Government-Surveyor of that Colony, and described in the 'Catalogue of the Fossil Organic Remains of Reptilia

* From κύων, a dog; and χάμψαι, the Egyptian name for the crocodile, applied by Wagner to the Indian Gavial.

and Pisces' in the Museum of the Royal College of Surgeons, 4to, 1854, pp. 97–106, there is a specimen, consisting of a portion, $2\frac{1}{2}$ inches in length, of a symmetrical pair of bones, each of a subtrihedral form, and joined together by the flattest of their sides. The description which I then gave of this fossil is as follows:—"Each bone increases in vertical, and decreases, but in a less degree, in transverse extent, the bones becoming more closely and extensively united together as they extend forward. Posteriorly, each bone is grooved near the middle of its inner flattened side, the grooves, when coadapted, forming a canal answering to that in a similar position on the elongated symphysial part of the lower jaw of the Gavial. At the opposite end of the fragment this canal is reduced to a fissure. The groove which divides the two bones, both above and below, at the back part of the fragment, contracts to a linear fissure as the bones advance and become more united together. The result of an extensive series of comparisons is, that the symmetrical bones in this remarkable fossil most resemble in shape the coadapted elongated dentary elements of the lower jaw of the Gavial and Teleosaurus: but they show no traces of alveoli, and, if they be parts of those bones, indicate a reptile either edentulous or with the teeth confined to the anterior extremity of the jaw" (p. 106).

The subsequent discovery of the fore end of the jaw of the Gavial-like reptile *Cynochampsa* adds to the probability of the above conjecture.

Vertebræ of Saurians from the same deposits of the Drakenberg afforded characters of the genera *Massospondylus*, *Pachyspondylus*, and *Leptospondylus*, which characters are given in detail in the volume above cited, and were further illustrated by figures and diagrams in my Lectures on Fossil Reptilia, delivered at the Museum of Practical Geology in 1858.

EXPLANATION OF PLATES I. II. & III.

Illustrative of Reptilian Remains from South Africa.

PLATE I.

Fig. 1. Side view of the skull of *Oudenodon Bainii*, one-half nat. size. [In the British Museum.]

Fig. 2. Side view of the skull of *Ptychognathus verticalis*, one-half nat. size. [In the British Museum.]

Fig. 3. Side view of the skull of *Ptychognathus declivis*, one-half nat. size.

Fig. 4. Back view of the skull of *Pt. declivis*, one-third nat. size.

Fig. 5. Top view of the cranium of *Pt. declivis*, one-third nat. size. [In the British Museum. Some distorted and dislocated parts have been restored in the figures; the letters and figures are explained in the text.]

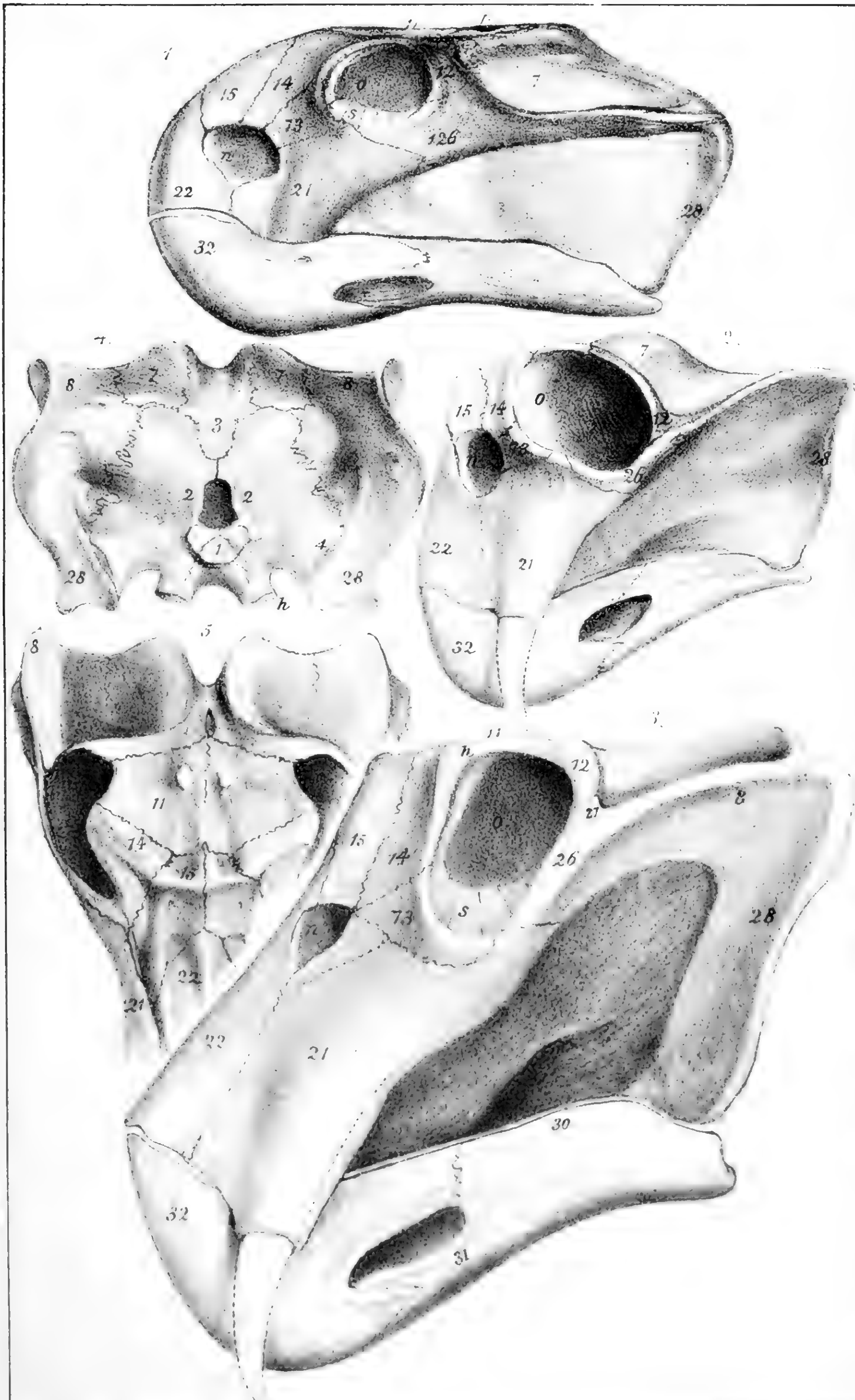
PLATE II.

Fig. 1. Side view of the skull of *Galesaurus planiceps*, showing the socket and part of the base of the upper canine, *c*, and the lower incisors.

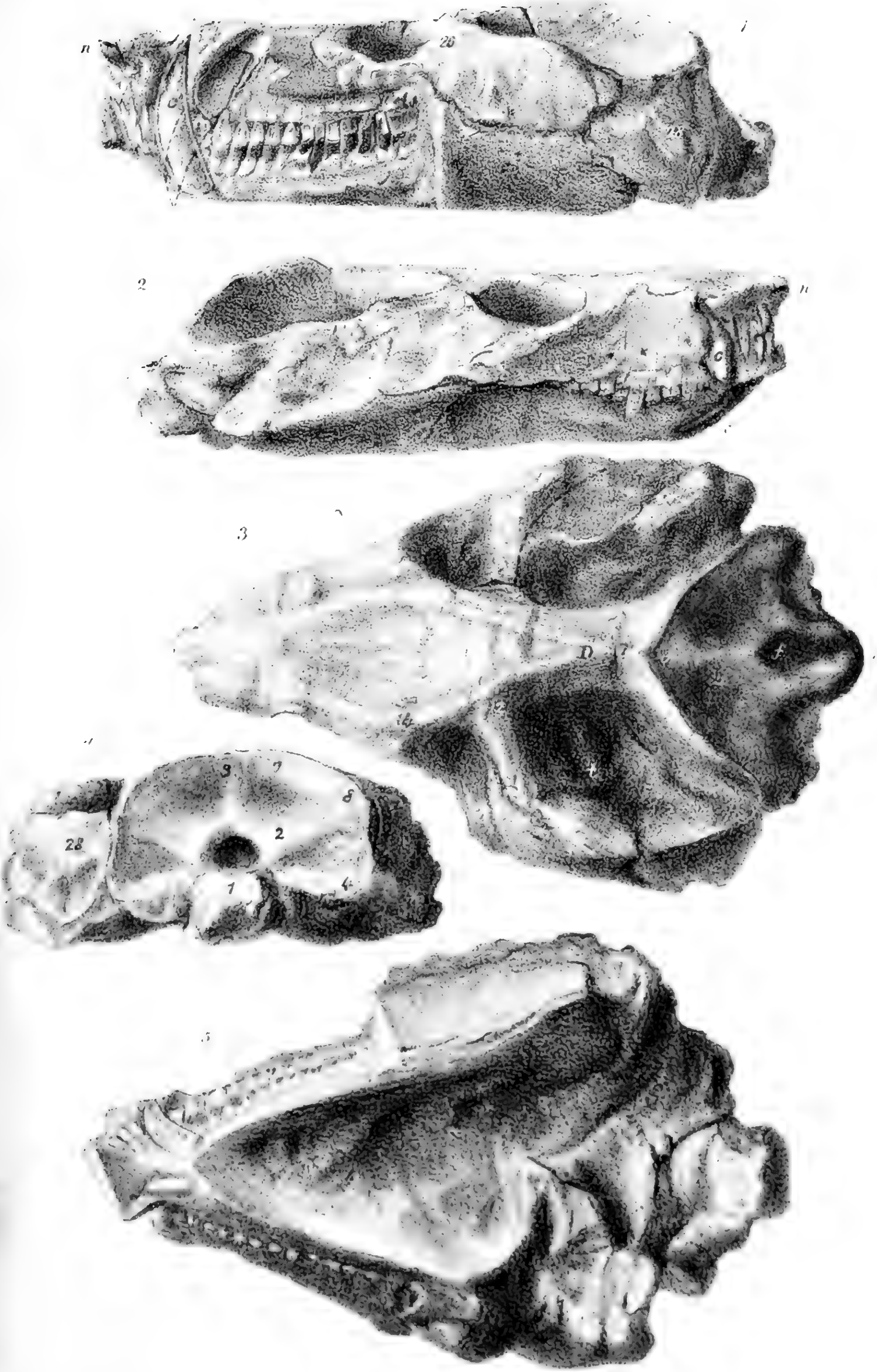
Fig. 2. Opposite side of the same skull, showing the base of the upper canine, *c*, *in situ*, and the upper incisors.

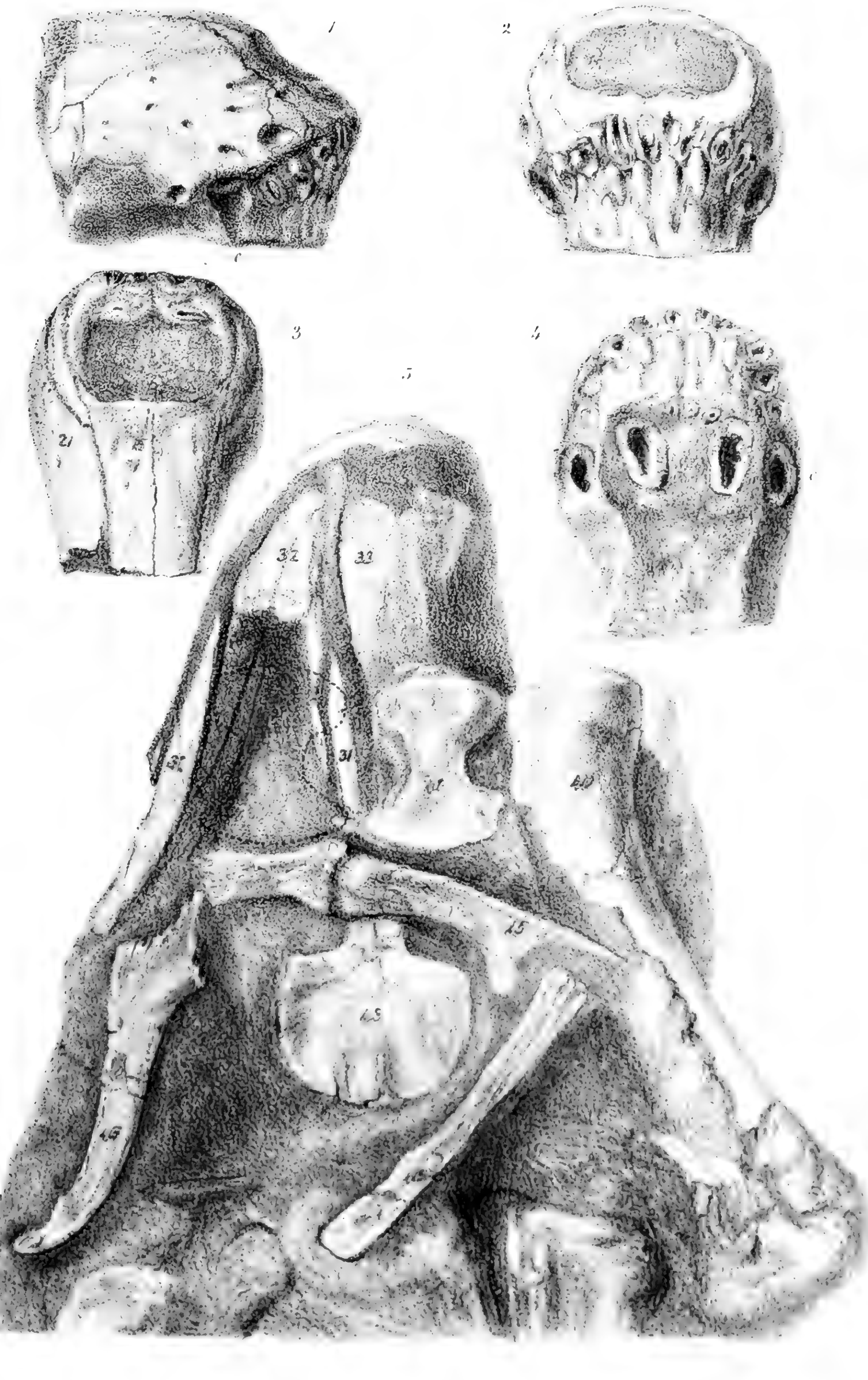
Fig. 3. Upper view of the same skull.

Fig. 4. Back view of the same skull.



Reptilian Remains from South Africa





Jos. Dinkel del. & lith.

Fig. 5. Under view of the same skull. [All the figures are of the natural size: the original is in the British Museum; the letters and figures are explained in the text.]

PLATE III.

Fig. 1. Side view of the fore end of the skull of *Cynochampsa laniarius.*
Fig. 2. Front view of the same.
Fig. 3. Upper view of the same.
Fig. 4. Under view of the same, showing the bodies and pulp-cavities of the fractured upper and lower canines, nat. size. [Original in the British Museum.]
Fig. 5. Under view of part of the skull, with the hyoidean arch and appendages, of *Oudenodon*, nat. size. [The original is in the British Museum; the letters and figures are explained in the text.]

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2. *On the* South-easterly Attenuation *of the* Lower Secondary Formations *of* England; *and the* probable Depth *of the* Coal-measures *under* Oxfordshire *and* Northamptonshire.

By Edward Hull, Esq., A.B., F.G.S., of the Geological Survey of Great Britain.

[Plate IV.]

Contents.

§ 1. *Introduction.*—The present is, perhaps, a fitting occasion for submitting to the notice of the Society the following ideas regarding the extension of the Lower Secondary Rocks in the direction of the

Thames Valley, as the focus of my remarks lies in the district of Oxfordshire, with the geological structure of which our learned President is so intimately acquainted.

My way has been, to a certain extent, prepared by the elaborate Essay "On the possible Extension of the Coal-measures beneath the South-eastern Part of England," by Mr. Godwin-Austen, communicated to this Society*. This essay and the researches of Mr. Prestwich have excited much interest regarding the rocks which underlie the Cretaceous and Oolitic formations. It is with the object of throwing some further light on this important subject that the following observations and deductions have been drawn up.

It is almost unnecessary to reiterate here what is now so fully understood, from the researches of D'Archiac, Rozet, Prestwich, and especially of Godwin-Austen, that along the line of the Franco-Belgian Coal-field the Cretaceous and Nummulitic rocks repose on the highly inclined edges of the Palæozoic Rocks without the intervention of those of the Lower Secondary periods. In the district of the Bas-Boulonnais similar phænomena are observable; but we learn from the memoir of M. Rozet that strata referred to the Great Oolite abut against the northern flank of the Palæozoic range and rest on a bed of Carboniferous Rocks †.

Adopting the theory of Mr. Austen regarding the extension of the Palæozoic axis of elevation under the Thames Valley, I do not, however, consider that the entire absence of all the intervening formations between the Great Oolite and the Coal-measures is to be attributed altogether to the presence of this old coast-line, but to other causes to be hereafter stated. I shall endeavour to show that *all these formations decrease in thickness, as they approach the south-east of England, from the failure of sediment,* in the manner of deposits forming at the mouths of large rivers.

I also propose to inquire whether the Uppermost Palæozoic rocks, namely the Coal-measures and Permian deposits, are regulated in their distribution upon a similar physical plan; or whether they may not have a much wider range, and extend into districts where many of the more recent formations cease.

Lastly, whether there are not reasons for concluding that under certain districts of Oxford and Northampton the Coal-measures lie at available depths below the surface, owing to the thinning away of the Lower Secondary rocks.

§ 2. *Distribution of the Lower Permian Beds of Central England.*—Upon comparing the Lower Secondary with the Uppermost Palæozoic formations, we discover a very marked difference in their distributions. We find the Bunter-Schiefer and Zechstein appearing only in the north-eastern districts of England, and the Rothe-todteliegende confined principally to the central counties and Salop; while the Trias is most fully developed towards the north-west.

Referring to the works of Sedgwick‡, Murchison§, Ramsay‖,

* Quart. Journ. Geol. Soc. vol. xi. p. 533.

† Rozet, 'Description Géognostique du Bassin du Bas-Boulonnais.'

‡ Trans. Geol. Soc. 2nd Series, vol. iii.

§ 'Siluria,' new edit.

‖ Quart. Journ. Geol. Soc. vol. xi. p. 185.

and other authors for descriptions of these rocks, I proceed to make some observations on the topographical distribution of the Lower Permian rocks or Rothe-todte-liegende.

The red and purple sandstones, marls, and brecciated conglomerates of which the Lower Permian formation is composed, attain their greatest development along a band of country stretching from west to east, including parts of the counties of Salop, Worcester, Stafford, and Warwick; while in the north-west districts of Cheshire, where the Trias has been deposited in great force, the Permian rocks are but sparingly represented.

I beg to call particular attention to this fact, because it shows how great has been the break in the order of succession, in consequence of considerable changes in the distribution of land and sea between the Palæozoic and Mesozoic epochs.

From sections published by the Geological Survey, traversing the Permian rocks of Enville in Salop, the thickness of the formation has been found not less than 1700 feet*. On both sides of the South Staffordshire Coal-field, the thickness is probably not less than this; and Mr. Howell's estimate of the maximum depth of the large mass of these red rocks in the neighbourhood of Coventry is 1800 feet†. The north-eastern limit of the formation appears to skirt the southern edge of the Leicestershire Coal-field; thence trending along a north-west line, it crosses the centre of the North Staffordshire Coal-field; from thence it may be traced at intervals northward into Scotland‡. Its westerly limit is the Denbighshire Coal-field. Its southern limit is not so easily defined, and this fact forms a most serious question in speculating upon the descending series of rocks which underlie the districts of Oxfordshire and Northamptonshire. It would be a subject for small congratulation if, on sinking for coal over these districts, it should be found that while the Lower Mesozoic rocks had become comparatively thin, the Permian formation existed in great force beneath. As Mr. Godwin-Austen has truly stated, such questions, in the absence of direct experiment, can be solved only by a restoration of the land-surfaces and coasts of the period; and, we may add, by a knowledge of the sources from which the sedimentary materials have been derived.

A. *Distribution of Land and Sea at the Lower Permian Period.*—There is the strongest evidence for believing that there was a much larger extent of land-surface during the formation of the Permian rocks than during that of the Trias. Professor Ramsay§ has demonstrated with, it appears to me, great probability, that the breccias which occupy a central position in the Rothe-liegende of Salop and Worcester are the ice-drifted *débris* of sub-aërial regions of the Longmynd and adjacent Silurian ranges. The Alberbury breccia ||

* Horizontal Sections, Sheet 53.

† Horizontal Sections of the Geological Survey, Sheet 51.

‡ See Mr. Binney, "On the Permian beds of the North-west of England," Mem. Lit. & Phil. Soc. Manchester, 1855. Also Prof. Sedgwick, Trans. Geol. Soc. 2 ser. vol. iv.

§ Quart. Journ. Geol. Soc. vol. xi. p. 185.

|| See 'Silurian System,' p. 48–49, where the author traces the origin of some of the fragments of the breccia to certain freshwater limestones of the Coal-measures.

is certainly the remnant of a shingle-beach, formed at the base of the Carboniferous Limestone ridge at the southern termination of the Denbighshire Coal-field; and the limestone-conglomerates which we find at intervals (in a zone lower than the trappoid breccia) over the whole of the Midland Counties are representatives of this shingle-beach. It is also to be noticed, that there is a strong lithological resemblance between the Old Red Sandstone of Herefordshire and Salop and the neighbouring Permian rocks; and I have long entertained the idea that the Lower Permian of the western districts is to a great extent a re-formation of the Old Red Sandstone, which once had a more extended range than at present, as is testified by the outlying masses capping the Ludlow rocks of Salop and Radnor. It would, therefore, seem that at the commencement of the Permian age the coast-line extended from the Abberley range northwards along a line nearly corresponding to the present limits of the Lower Carboniferous and Silurian rocks of Wales and Salop. From the Flintshire Coal-field eastward to that of North Staffordshire, there probably existed a channel deepening towards the centre, and forming a basin for the Permian deposits in the direction of Lancashire. The axis of elevation of the Carboniferous range of the Penine chain continued along the borders of Charnwood Forest; and, considerably east of the present edge of the Warwickshire Coal-field, formed the land towards the north-east; and upon the prolongation of this barrier, which seems to stretch in a E.S.E. direction, depends the existence of the Lower Permian rocks under Northamptonshire*.

Considering the great thickness of the Permian rocks in Warwickshire, it is improbable that they have been formed altogether of the Older Palæozoic rocks of Wales and Salop. The bed of calcareous conglomerate, which occupies a nearly central position, is composed of pebbles of Carboniferous Limestone and Silurian rocks, and indicates the proximity of land. The rocks of Charnwood Forest may possibly be a portion of the western prolongation of that Palæozoic dry land which, according to Mr. Godwin-Austen, occupied the German Ocean at this period. If so, the Lower Permian strata would appear to have been accumulated within a comparatively narrow channel or longitudinal basin, the axis of which stretched from the valley of the Eden towards the south-east, in which direction the channel became wider. The western border trended due south towards the Bristol Channel; and the eastern probably curved round towards the German Ocean†. We cannot with cer-

* It should be here stated that, as the Warwickshire Coal-field has been thrown up along its north-east edge by a fault of considerable magnitude, there is every probability that both Permian rocks and Coal-measures exist to the N.E. of this fault, extending to the barrier, which may be considered as indicated by the trappean bosses of Stoney Stanton.

† Both Mr. Godwin-Austen and Mr. Sorby, from independent data, have shown the probability of land having existed during a portion of the Upper Palæozoic and Mesozoic periods over the area occupied by the German Ocean; and in this view the author concurs, from considerations connected with the distribution of the Permian rocks.

tainty define the southern limit of the formation under the districts of Oxfordshire and Northamptonshire; but, recollecting the absence of these rocks below the Chalk near London, Boulogne, and the Franco-Belgian Coal-field, it is probable that they become attenuated southwardly from Warwickshire. From considerations founded on current-structures, Mr. Sorby seems to have arrived at a similar conclusion.

§ 3. *South-Easterly Attenuation of the Lower Secondary Rocks.*

1. *The Trias.*—A. *Bunter Sandstone.*—Our inquiries commence with this formation, which introduces the Mesozoic Series, and rests unconformably on all the rocks of Palæozoic age. Attaining its highest development towards the north-west, it composes the plains of Cheshire and Lancashire; it fills the beds of old Palæozoic valleys, as those of the Eden, the Clewyd, and Belfast Lough; and from its position along the sea-coasts of Ireland, the Isle of Man, North Wales, Lancashire, and Cumberland, it probably forms a large portion of the bed of the Irish Sea.

It is, however, only recently, since the detailed examination carried out by the officers of the Geological Survey, that anything like a just estimate of the stratigraphical importance of this formation has been arrived at. It has been classified into three subdivisions, sufficiently marked to enable us to compute the depth of the formation in any given district, and such as allows us in the present inquiry to arrive at definite results.

From a section across the plain of Chester, and Delamere Forest, we obtain the following vertical measurement of these subdivisions in this district*.

Bunter Sandstone, Cheshire. North-west District.

3. Upper mottled Sandstone	700 ft.
2. Conglomerate-beds	750
1. Lower mottled Sandstone	700
Total thickness	2150

The general succession of the Trias in North-west Cheshire is shown in Pl. IV. fig. 2.

A few miles further south, at Holt, another section gives the thickness of the Bunter Sandstone at 1600 feet; and a third, across Bridgenorth, in Salop, shows nearly the same result.

Now, whenever we follow these beds eastward, from their furthest western outcrop, we invariably find that they decrease in thickness; some of the subdivisions more rapidly than others. In the counties of Derby, Stafford, Leicester, and Warwick, the 1st and 3rd subdivisions are generally absent, or only sparingly represented. The Conglomerate-beds predominate frequently where the other subdivisions have disappeared; but when we cross to the eastern borders of the Leicestershire and Warwickshire Coal-fields, this most constant subdivision thins away. We find the Lower Keuper Sandstone resting directly on the Coal-measures at Ashby, and

* Horizon. Sect. of the Geol. Survey, Sheet 43.

Coleorton in Leicestershire, and on the Permian Rocks further south at Warwick,—the whole of the Bunter Sandstone having consequently thinned out.

B. *Keuper.*—We now proceed to trace the range of the Keuper, under its two principal subdivisions—the Lower Keuper Sandstone, and Red Marl. The former of these is frequently introduced by a band of hard calcareous breccia, with laminated red shales, which is succeeded by evenly bedded ripple-marked sandstones and marls (called "Waterstones" by Mr. Ormerod*). In Cheshire and Lancashire, the Lower Keuper Sandstone reaches a thickness of 450 feet, forming the scarped ranges of the Runcorn, Delamere, and Peckforton Hills. These beds have been traced on the maps of the Geological Survey over the western and central counties; and, as a general rule, they are found to decrease in thickness in proportion as they approach the South-eastern counties. Around the skirts of the Leicestershire Coal-field this subdivision has a general thickness of 200 feet; and over the centre and the eastern side it rests immediately on the Coal-measures, without the intervention of the Bunter Sandstone. The district around Warwick is that along which it becomes most rapidily attenuated, and where it is on the point of being ultimately concealed by the Red Marl. As in the case of the Leicestershire Coal-field, the Lower Keuper Sandstone is here the most ancient member of the Trias, and I am informed by Mr. Howell, of the Geological Survey, that its thickness may be estimated at not more than 150 feet.

Comparing, then, the thickness of this subformation where it is visible for the last time towards the south-east with that which it assumes in West Cheshire, we find that it has decreased by two-thirds in its extension from the one locality to the other; the horizontal distance being 85 miles. Now, if this decrease continues in the same proportion, the whole subformation ought to disappear several miles N.W. of Oxford† (Plate IV. figs. 2, 3, 4).

C. *Red Marl.*—The thickness of the Red Marl in Cheshire has been much under-estimated. From considerations connected with the depths of the salt-beds, Mr. Ormerod estimates it at more than 700 feet‡; but I feel sure he will allow that these data can scarcely afford even an approximate computation, as we are still uncertain of the nature of the beds which underlie the salt-rocks, and of the position of those through which the shafts have been sunk at Northwich.

A very perfect section along the banks of a brook (without a name in the Ordnance Map), three miles south of Malpas, although it does not extend nearly to the top of the formation, shows the Red Marl to be of much greater thickness than it is generally considered. The beds, consisting of fine laminated red and grey shales, may be

* Quart. Journ. Geol. Soc. vol. iv.

† Maps of the Geol. Survey, 53 N.W.—63 S.W.

‡ Quart. Journ. Geol. Soc. vol. iv. p. 288. For local descriptions of the Triassic Rocks of Cheshire and Lancashire, see the Memoirs of Messrs. Binney, Ormerod, J. Cunningham, and R. Rawlinson in the Journal of the Geological Society.

traced for a distance of two miles, with an average dip of 15° to the S.E. From this section alone a thickness of 2300 feet may be estimated; and, judging from the interval between the point where the section ceases and the Lias boundary at Whitchurch, the thickness must be much greater. From various comparisons it appears probable that from 3000 to 3500 feet is not an over-estimate. Now, in Staffordshire, Leicestershire, and the central districts generally, the Red Marl does not exceed a thickness of 600 or 700 feet, showing a great decrease towards the S.E. from Cheshire (Plate IV. figs. 2, 3).

The *direction of maximum attenuation*, however, is along a line drawn S.E. from the Estuary of the Dee, and passing near Nantwich, Stafford, and Warwick, beyond which the formation is lost below the Lias. If we put down as the thickness at each of these places respectively, 3000, 700, and 400 feet, we shall have probably a just conception of the rapid thinning-out of these beds; and it therefore appears by no means improbable that even this great argillaceous series is extremely thin, or altogether absent, in Oxfordshire and Northamptonshire.

If, then, we compare the section of the Trias, as it occurs in Cheshire and East Warwick, we find the following result:—

		feet.
Cheshire	Red Marl	3000
	Lower Keuper Sandstone	450
	Bunter Sandstone	2150
	Total	5600
East Warwickshire	Red Marl	400
	Lower Keuper Sandstone	200
	Bunter Sandstone	absent
	Total	600

In other words, the formation is ten times thicker in the former than in the latter county.

2. *Claim of the Trias to Consideration.*—A formation which attains so great a development deserves, I think, a larger share of attention than it has yet received from geologists. There are few groups which, in the almost entire absence of fossils, have so strongly stamped upon them the impressions of varying physical changes during their growth. We find in it stages which have been strongly influenced by current-action, and others of apparent tranquillity. We find shingle-beaches, some traceable to their coast-lines, and conglomerates which have been drifted from regions comparatively remote.

Its structure, however, presents phænomena of much interest to the physical geologist. It is frequently traversed by systems of faults, which, in the form of escarpments, ridges, and valleys, have left their marks in the configuration of the surface*; and no person

* In many districts of Cheshire, Salop, and Staffordshire, the co-ordinate lines of fracture, with their cross-fractures, may be very readily traced by the features

who has visited the districts of Alton, Cheadle, and Trentham, or climbed the escarpments of the Hawkestone, Peckforton, and Runcorn ranges, can deny to the New Red Sandstone an amount of scenic power almost comparable with that of the Oolites of Gloucestershire.

3. *Lias.*—A. *Lower Lias.*—We have not, unfortunately, the same facilities for making comparisons of the development of the Lower Lias in the Western and Eastern Districts. With the exception of the outlier at Prees in Shropshire, and a newly discovered area of the same formation near Carlisle*, we have no districts of comparison; and, as these do not present us with the whole ascending series, they are useless for our purpose. I therefore propose to treat this formation by analogy. It must be allowed that there is a close connexion between the Lower, Middle, and Upper Lias formations. As far as we can judge, the strata are strictly conformable. There are no breaks greater than between different subdivisions of the Inferior Oolite. There is a generic community of the fauna; and the mineral characters of the series are repeated at intervals throughout. We are, therefore, justified in supposing that all the Liassic formations of central England have had their origin from the same sources and under similar physical conditions, and are therefore equally subject to attenuation when receding from those sources. If, therefore, it can be shown that there is a tendency on the part of the Marlstone and Upper Lias to thin away towards the south-east, and that this attenuation takes place within the range of actual observation, there will be strong grounds for inferring a similar propensity on the part of the Lower Lias; at least, it is upon these grounds that I base the analogy. When we come to consider, in a subsequent part of this paper, how strong are the reasons for believing that all these formations have been derived from regions lying to the north-west of the British Islands, the analogy will be found to gain additional force.

B. *Marlstone.*—Let us now trace the Marlstone along its S.E. extension towards Oxford. At Bredon Hill (see Plate IV. fig. 1), a large outlier near the confluence of the Avon and Severn in North Gloucestershire, the Marlstone attains a thickness of 250 feet; probably the greatest known in this part of England. On the flanks of Ebrington Hill, the extreme northern termination of the Cotteswold Range, the thickness, as computed by Mr. Howell, is 150 feet†; at Leckhampton Hill, near Cheltenham, the thickness is 115 feet‡, by accurate measurement, which is the average development of the formation along the whole of the Cotteswold Hills.

of the surface, by one who possesses a perfect knowledge of the succession of the beds. These faults admirably bear out the principles laid down by Mr. Hopkins of Cambridge, followed by Mr. Jukes and Professor Haughton.

* Recently communicated to the Manchester Geological Society by Mr. Binney. See also Quart. Journ. Geol. Soc. vol. xv. p. 549.

† "Geology of the Country around Cheltenham," Mem. Geol. Survey, 1857, p. 19.

‡ *Ibid.* plate 2.

If we trace these beds towards the borders of Oxfordshire, along the Valley of the Evenlode, that is, in a direction E.S.E. from Bredon Hill, we find a marked diminution in the thickness. At Burford, Shipton, and Charlbury, the farthest points where the thickness of the Marlstone can be ascertained, we find it to have dwindled down to an average of 20 feet, or less than one-tenth of its amount at Bredon. If, therefore, this attenuation continues in nearly the same ratio, the formation cannot extend far beyond the city of Oxford. It is remarkable, however, that the "Upper Rock-bed" shows far less disposition to thin out than the underlying sandy strata, which, in Gloucestershire form nine-tenths of the mass of the formation.

C. *Upper Lias.*—In the case of the Upper Lias Shale, the south-easterly attenuation is even more decided. Its thickness at Bredon Hill is nearly 400 feet*; but at Leckhampton Hill it reaches 230 feet, including a few beds of superimposed sands. From this point eastward the formation thins away; and at Stonesfield, in the Valley of the Evenlode, it may be said to have finally disappeared, being represented only by a band of shale four feet thick; the Inferior Oolite resting almost immediately on the Marlstone "Rock-bed," which has here become a valuable iron-ore†.

As we can thus, from actual observation, prove the south-easterly thinning-out of the Middle and Upper Lias, I think, bearing in mind their close relationship to the Lower Lias, that we are justified in inferring a somewhat similar thinning-away towards the Thames Valley on the part of this earliest formed member, though it has probably a more extended range. Should this supposition prove correct, the whole Liassic Series should be on the point of disappearing below Oxford.

I here wish to repeat that in the case of the Lias the line of maximum attenuation follows an E.S.E. direction. A deviation of a few degrees northward produces a considerable change in the thickness of the beds. Thus in the neighbourhood of Chipping Norton and Deddington, which are nearly due east of Cheltenham, the combined thickness of the Upper Lias and Marlstone is not less than 200 feet.

4. *Inferior Oolite.*—Proceeding next to the consideration of the Inferior Oolite, I take as sections for comparison those at Cleeve Cloud and Leckhampton Hill at the west, and those of the Valley of the Evenlode at the east. The formation at Cleeve Cloud is probably not less than 300 feet thick, and that at Leckhampton Hill 264 feet. This latter, ever since the original survey of Murchison‡, has been regarded as the typical section of the Inferior Oolite, not only for England, but for Europe. It there consists of

* Ascertained from a measured horizontal section about to be published by the Geological Survey. Bredon Hill is the most north-westerly district where the Upper Lias exists; and its great thickness there shows the rapidity of the thinning-out towards Oxfordshire.

† See Map of the Geological Survey, Sheet 45, S.W.

‡ Proceedings Geol. Soc. vol. i. p. 388.

five well-pronounced subdivisions, the horizontal range of which throughout the Cotteswold Hills, towards the borders of Oxfordshire, I have already described in a Memoir on the district*. Without entering here into details, I will content myself with stating the following conclusions. The Pea-grit has the smallest range; next the Upper Freestone; then the Oolite-marl and Lower Freestone; and the most persistent member is the Ragstone, which, though never surpassing a thickness of 50 feet, stretches eastward into Oxfordshire, and there becomes the sole representative of the Inferior Oolite.

I find that this easterly attenuation of the Inferior Oolite is noticed by Professor J. Phillips†, and I refer to it especially as illustrating how small is the relationship between vertical depth and horizontal range. In the case of the Oolites we find that those beds in which there is evidence of current-action, and where the fossils are fragmentary and drifted, the horizontal area is small; of this the Freestone Series is an example; but where the beds have been tranquilly deposited, and the fossils have been buried where they lived, the range is greater; and this is a law more or less applicable to all the sedimentary rocks of which I am treating.

In the Valley of the Evenlode we can trace the Inferior Oolite as far as Stonesfield, and there it has a thickness of about 15 feet; but farther east, in the Valley of the Cherwell, at Rousham, it has altogether disappeared, and we find the Great Oolite resting immediately on the Upper Lias Clay, or only separated by a thin stratum of ferruginous sand, which must be referred to the Great Oolite‡.

The case of the Inferior Oolite entirely disappearing within a distance of 30 miles south-east of the point where it attains a thickness of nearly 300 feet is remarkable, because it cannot be regarded altogether in the character of a sedimentary deposit. Many of the Freestone-beds have the characters of shelly gravel, drifted by currents, and these are less persistent; others, as the Oolite-marl and Ragstone, are partly of organic and chemical origin. It is remarkable that the line of maximum attenuation occupies a nearly parallel direction with that of the more mechanically formed rocks, such as the Lias.

5. *Fuller's Earth.*—Of the Fuller's Earth it is only necessary to state that it does not extend as far east as Oxfordshire. In the Cotteswold Hills we meet with it for the last time at Sherborne, near Burford§. But the formation is deserving of notice as being the oldest amongst the Lower Secondary Rocks in which the direction of maximum attenuation changes from the south-east to north-east. In Somersetshire it attains a thickness of 120 feet.

6. *Great Oolite.*—The Great Oolite of Gloucester, Oxford, and

* "Geology of the Country around Cheltenham," 1857; Mem. Geol. Survey.

† 'Manual of Geology,' p. 303.

‡ Sheet 45, S.W., of the Geological Survey Map; and "Geology of the Country around Woodstock;" Mem. Geol. Survey, p. 14.

§ "Geology of the Country around Cheltenham," p. 52.

Northamptonshire divides itself into two well-marked zones*. The Lower Zone includes the Stonesfield Slate, as well as clays, shelly oolitic freestones with current-lamination; and lastly, those thick beds of ferruginous sands which are so largely developed in Northamptonshire. The Upper Zone, on the other hand, is extremely distinct, consisting of evenly bedded limestones, weathering white, with bands of calcareous marl. The fossils of the Upper Zone are seldom fragmentary, though generally in casts, and appear to have been buried where they lived. As might be expected, the horizontal range of these two zones is very unequal, and, on the whole, they probably represent, respectively, shallow- and deep-sea conditions of the Great Oolite.

These two zones range probably from Yorkshire, and certainly from Lincolnshire, as may be gathered from the description of the Oolites of Lincolnshire by Professor Morris†, and from thence into Northamptonshire and Oxfordshire.

The Lower Zone attains its greatest development towards the western escarpment of the Oolites of Wiltshire and the centre of the Cotteswold Hills; but eastward it dwindles down until it entirely dies out in the Valley of the Cherwell, near Woodstock.

The same south-easterly attenuation is also observable in the case of the Forest-marble, which may be considered a subformation of the Great Oolite‡. Thus we have reason for concluding that under the Oxford Clay of a large portion of Northamptonshire and Oxfordshire, we should pass from the Cornbrash into the Upper Zone of the Great Oolite, and from this into the Marlstone, the intervening beds having disappeared.

From internal evidence over an extensive range, afforded by the evenly bedded limestones and marls of the Upper Zone of the Great Oolite, and from its continuity over an area extending at least from Somersetshire to Lincolnshire, combined with the fact that it furnishes no evidence of a tendency to thin away towards the south-east, I am inclined to think that this subdivision extends as far as the Palæozoic barrier of the Thames Valley, and that it is the identical part of the formation described by M. Rozet as resting upon the Carboniferous rocks of the Bas-Boulonnais. It is the *first exception* to south-easterly attenuation we meet with in ascending through the Mesozoic rocks of England; and it cannot be regarded as a drifted sedimentary deposit, but as one which, like the White Chalk, was formed on the bed of a comparatively deep sea by the agency of living animals, or by the precipitation of the fine calcareous mud derived from Molluscs, Corals, and Foraminifera.

* *Op. cit.* p. 53.

† Quart. Journ. Geol. Soc. vol. ix. p. 334. The beds which in Lincolnshire succeed the ferruginous limestone, considered by Professor Morris as Inferior Oolite, are "stratified sands and clays, local in their occurrence, bearing plant-remains." These beds represent the "Lower Zone" of the Great Oolite, and are succeeded by marly white oolites, "indicating deeper-sea conditions," which represent the "Upper Zone."

‡ This formation dies out in the Valley of the Cherwell, east of Woodstock. See Map of Geol. Survey, Sheet 45, S.W.; and "Geology of Woodstock," p. 21.

With the Upper Zone of the Great Oolite, the earliest Secondary formation which does *not* thin away south-eastward, our investigations cease on this head, and I now propose to inquire what are the probable positions of the Palæozoic rocks under this district.

I can here avail myself of the opinions of other authors, which will render it unnecessary to dwell to a great length on this part of the subject.

§ 4. *Probable Extension of the Coal-measures from Warwickshire to the Thames Valley.*—This is a subject on which it is necessary to exercise much caution, on account of the interests involved. Mr. Godwin-Austen has already stated his opinion of the probable extension of the Coal-measures from the Coal-fields of Stafford and Warwick, to join that band which he considers to stretch along the Thames Valley under the Chalk. Even if this be the case, there may be interruptions in the form of bosses of Silurian or Cambrian rocks, and the measures themselves may be generally unproductive of valuable coal-beds.

In fact, there are evidences that the Coal-measures become attenuated towards the S.E., from phænomena observable in the Warwickshire Coal-field. At the southern extremity of the Coal-field, south of Bedworth, all the coal-beds, which towards Atherstone are more or less widely separated by sandstones and shales, become united into one mass 30 feet thick*. At the same time the south-easterly strike of the Coal-measures and Permian rocks in the Warwickshire district shows that they tend to underlie Oxfordshire and part of Northamptonshire; and the strike of the coal-beds has been proved to continue in the same direction for a considerable distance underneath the New Red Sandstone†. Further to the south, near Coventry, the Permian Beds slightly change their strike *towards the east*, and, if there be any conformity between this formation and the Coal-measures, which seems to be the case in this district, the dip of the Coal-measures must be in the direction of Oxfordshire. Of course beyond this district we have no further means of judging by actual observation whether this direction of the beds continues; but it is satisfactory to find, at the last place where the Coal-formation can be seen to the S.E., the beds tending to underlie a district where we know that the superimposed formations have become greatly lessened in depth.

§ 5. *Physical Geography of the Trias.*—A. *Land on the North Atlantic Area.*—At the close of the Permian Period, those disturbances accompanied by marine denudation ensued which changed the distribution of land and sea, and produced a high degree of unconformity between the Permian and Triassic Rocks. Their general effect was to extend the area of sea, and to contract the land-surface, so that the British Islands presented the appearance of a small polynesia, in place of a more or less connected line of

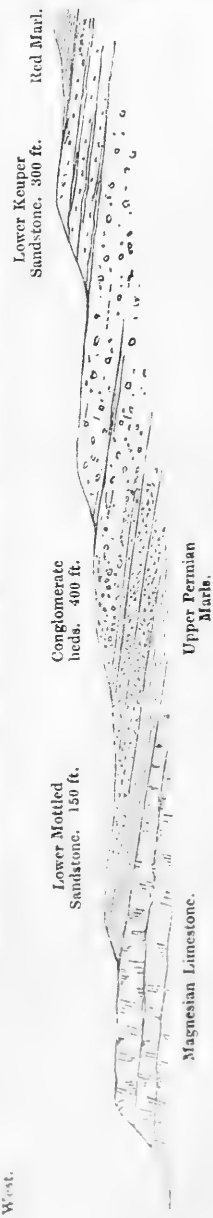
* Geol. Survey Map, Sheet 63, S.W., and Vertical Sections, Geol. Survey, Sheet 20.

† As I am informed by my colleague Mr. Howell. See Geol. Map, Sheets 53, N.W.–63, S.W.; and "Geology of the Warwickshire Coal-field," 1859.

coast stretching westwards, northwards, and eastwards along the margin of the Lower Permian basin. The whole of the low-lying district between the highlands of Wales and those of Cumberland was submerged, and a channel was opened for the transport of Triassic sediment by an oceanic current from the north-west, by the agency of which it was spread over central England as long as the various kinds of sediment were capable of being mechanically suspended.

The Lower Carboniferous Range of the Penine Chain, which during the deposition of the earlier Permian strata was elevated into land, appears to have been completely submerged under the Triassic sea. This is presumed, independently of other considerations, by the fact that we find the same succession of Triassic beds on both sides of this range. In Nottinghamshire and Yorkshire, with the exception of the "Upper Mottled Sandstone," which has thinned out, we find exactly the same succession of subformations, both of the Bunter and Keuper, as in Lancashire and Cheshire. Now it will be shown presently that all the sediment has been transported from the north-west *towards the east and south,* so that the strata must have been deposited continuously across this portion of Northern England,—an evident proof that there was no separating barrier of land.

Thus, at Mansfield we find the following section across the Trias, in which the same subformations occur as at Chester (with the one exception), while, at the same time, the whole series is considerably lessened in thickness. The section has been drawn from the information supplied by my colleague Mr. Talbot Aveline.



General Section across the Permian Rocks and Trias, near Mansfield.

Farther north, at Worksop, on the borders of Yorkshire, the succession is the same; so that we have here strong evidence, if not absolute proof, that these beds were continuous from Lancashire to Yorkshire, right across the Carboniferous Range.

The Silurian regions of Wales and Salop were also submerged and buried under Triassic sandstones to a considerable extent

at the close of that period. In the Valley of the Severn we find two distinct shingle-beaches, one in a position 450 feet above the base of the Bunter Sandstone, and the other about 500 feet higher. If these beds be reduced to their original horizontal position, and the whole brought below the sea-level, it would lead one to believe that all the area below 2000 feet at least was under the sea. The subsidence continued, with occasional pauses, throughout the Triassic epoch; and the extreme fineness of the sediment of the Keuper sandstones and marls proves the remoteness of the land from which it had been drifted. During the earlier stages of the Bunter series, the siliceous sediment appears to have been drifted over the plain of Central England, through the channel formed by the mountains of Westmoreland on the north and those of Caernarvon and Denbigh on the south, filling in all the old channels and valleys; and, as the later periods of the Keuper and Lias progressed, these old headlands gradually became more contracted both in area and elevation.

At the close of the period of the Bunter Sandstone, the low-lying tracts of England were probably elevated into dry land, and remained so during the deposition of the Muschelkalk in Germany. I have arrived at this conclusion from the following considerations.

B. *Subaërial conditions during the formation of the German Muschelkalk.*—The base of the Keuper is almost invariably a breccia or conglomerate, the pebbles of which can be identified with those Palæozoic formations in the neighbourhood which at the close of the Bunter period formed the coast. This breccia is, in fact, a shingle-beach; and, if we suppose the flat tracts of the Bunter to have been re-submerged at the commencement of the Keuper period, such a shingle-bed would be the inevitable result of the waves acting along a newly formed, and sometimes a bold, line of coast. Shallow seas and intertidal conditions prevailed throughout the higher stages of the Lower Keuper Sandstone; for we frequently find the footprints of Reptiles, sun-cracks, and rain-prints, showing that during the ebb of the tide the sea-bed was left dry.

C. *Unconformity of the Keuper and Bunter.*—There are evidences which appear to me irresistible that the strata of the Bunter and Keuper are unconformable. I have already shown the probability of this being the case in Germany, from the occurrence of pebbles of Bunter Sandstone in the Lower Keuper Sandstone of the Odenwald*, and the evidences in this country are equally strong. In the district of Alton, in Staffordshire, the base of the Keuper is formed of a white conglomeratic sandstone, resting on red shale; and its pebbles can only be referred to the reconstructed materials of the Bunter. They consist of the well-known, rounded, and coloured quartz of which we have no examples in England except from the conglomerate-beds of that formation. The Bunter conglomerates climb up the flanks of the Carboniferous rocks of Derbyshire; and, if this be the correct interpretation of their reappearance, they have

* Quart. Journ. Geol. Soc. vol. xiv. p. 224.

been elevated into a marginal coast at the commencement of the Keuper period; and this would have necessarily produced a certain degree of unconformity between these two formations of the Triassic Series.

The relative position of the Bunter and Keuper in Leicestershire appears to afford evidence of unconformity. The conglomerate-beds of the Bunter are confined to the western and northern portions of the Ashby-de-la-Zouch Coal-field, where they attain a thickness of 200 or 300 feet. Along a line passing N.E. and S.W. through Moira they terminate abruptly; and east of this line we find the Lower Keuper Sandstone resting immediately on the Coal-measures. These conditions would seem to indicate,—first, that after the deposition of the conglomerates certain disturbances had occurred, elevating the south-eastern districts, and thus causing the denudation of the conglomerates from off that area; and, secondly, that, after these disturbances (involving, of course, an unconformity), the beds of the Keuper had been deposited where we find them, resting on the conglomerates of the Bunter in one direction and on the Coal-measures in the other.

In Lancashire, near Ormskirk, there is a section showing the superposition of these formations, in which the appearance of unconformity is of so satisfactory a nature that it elicited the assent of such a cautious observer as Professor Ramsay. As the geology of this district has not yet been published by the Geological Survey, I do not feel at liberty to describe this section, but will only add that it is seldom that a more evident case of unconformity is laid open to view.

In thus stating my conviction that these formations are unconformable, I by no means wish to assert that the non-parallelism of the beds is ever very great; it is only sufficient to prove that disturbances and denudation have intervened between the two periods one effect of which was to place the bed of the Bunter Sandstone sea beyond the reach of marine deposition, and thus account for the entire absence of the Muschelkalk in England.

I shall close this subject, which I feel I have very imperfectly treated, with one more remark. It is scarcely possible to estimate the advantage, both to science and to civilization, which has resulted from the present configuration of the Mesozoic rocks of England. Keeping in mind the tendency which they exhibit to thin away towards the south-east, it is evident that, with their present strike and inclination, they are presented to us in succession along lines of fullest development. In order to estimate this more fully, we have only to reflect how dwarfish would have been the ascending series of formations, had they been upheaved along an axis coinciding with the present escarpment of the Chalk from Reading to the German Ocean. Such an arrangement would also have shut out all hope of reaching coal in the central counties, as the Carboniferous rocks would have been covered by the newer formations over the regions of their greatest vertical thickness.

D. *Causes of Variations in the Persistency of Strata.*—The facts here stated regarding the thinning-away of the various kinds of strata bear out in a remarkable manner the views laid down by Sir C. Lyell in his 'Principles of Geology.' When rivers carry down to the sea fragmentary rocks, sands, and mud, of various degrees of coarseness, these materials are brought within reach of marine currents, and are by their means spread over the bed of the ocean. The larger fragments are the first to become imbedded; while the more minute particles of sand or clay are carried to great distances out to sea, and slowly sink to the bottom, forming shales and clays, like those of the Red Marl, and Lias. Of these phænomena, the Triassic group produces examples. In Cheshire, where that formation is most fully developed, the Bunter and Keuper are of nearly equal thickness; but we have seen that the beds of the Bunter, which are formed of siliceous particles, more or less coarse and of a rather high specific gravity, do not reach as far to the south-east (that is, *out to sea*) as the eastern borders of Leicestershire and Warwickshire, where the fine muddy strata of the Keuper are still 500 feet in depth. The case is further illustrated when we compare the limited range of the breccias, or shingle-beaches, with the other beds of the Trias. These are never found to extend far from their parent coast-lines.

In observing individual beds also, we find a marked connexion between horizontal area and tranquillity of deposition. Those strata exhibiting the agency of local marine currents, which have produced the phænomena of false-bedding, are invariably inconstant, and, as it were, short-lived; while the evenly bedded layers, in which the fossils (in the case of fossil-bearing rocks) are entire, have much wider ranges. As points of comparison, we may place on the one side the two Mottled Sandstones of the Bunter and the shelly Freestones of the Inferior and Great Oolites, and on the other the Lower Keuper Sandstones, the Ragstones of the Inferior Oolite, the Upper Zone of the Great Oolite, and the Cornbrash.

§ 6. *Apparent South-easterly Attenuation of Carboniferous Series.*—I believe that the conclusions here stated regarding the south-easterly attenuation of the Lower Mesozoic rocks are applicable, to some extent, to the Carboniferous rocks of Britain. The Lower Carboniferous rocks are more largely developed in Scotland than in the North of England; and my colleague Mr. Geikie informs me that the sandstones and shales of the Lothians evince a marked tendency to become thicker towards the north-west.

Professor Phillips* appears to have arrived at a similar conclusion with respect to the "Yordale Rocks" of Yorkshire; and he has shown how the sandstones, shales, and other sedimentary strata thicken towards the north-west; while the organically formed limestones appear in greatest force in an opposite direction. I have already alluded to the example in the case of the Warwickshire Coal-

* Geology of Yorkshire, p. 176. See also Explanation of the Horizontal Sections of the Geological Survey, Sheet 45.

field; and a still more remarkable one occurs in South Staffordshire, where the "Main Coal" of Dudley, 10 yards thick, becomes split up into several seams at the northern part of the coal-field, and separated by sandstones, shales, and clays, altogether attaining a thickness of 300 feet. This fact has been demonstrated by Mr. Jukes*, who remarks upon the great persistency of the coal-beds as compared with the inorganic materials. The Yordale series of Lancashire and North Staffordshire are enormously developed in comparison with their equivalents in Leicestershire and Warwickshire. With all these facts in view, it is much to be feared that the Carboniferous Series generally becomes greatly reduced, and probably much less productive of coal, under the districts of Oxfordshire and Northamptonshire.

Mr. Sorby† has also carried on a series of investigations on the currents of these ancient seas, as indicated by the various phænomena of stratification. It is probable that, when completed, these will lead to results of the highest interest in throwing light upon the physical geography of past times. In the meantime Mr. Sorby appears to have arrived at the conclusion, that the drifting of sediment has been from the N.W. in the case of the Carboniferous group; while tidal currents ebbed and flowed in N.E. and S.W. directions throughout parts of the Permian and Oolitic periods‡. All these phænomena point to the existence of a continent, or at least of an extensive tract of land, throughout the Carboniferous, Permian, and Lower Secondary Periods in the region now occupied by the North Atlantic Ocean.

Accepting, then, the conclusions of Mr. Godwin-Austen, that a band of Coal-measures stretches along the Thames Valley, thrown off on the north side of the Old Palæozoic Axis, it is not improbable that the formation extends, with perhaps occasional interruptions, into the central counties; but I have already hinted at the probability that, as a coal-producing set of rocks, it has become deteriorated in its extension southwards (page 74).

With regard to the formations which may be inferred to lie above the Coal-measures in Oxfordshire and Northamptonshire, it is probable we should find the following ascending series:—

1st. The Lower Permian rocks, of considerable depth northward, but diminishing in thickness towards the escarpment of the Chalk.

2nd. Above the Permian beds, we should find no Bunter Sandstone, but only the Keuper Marls, greatly diminished in thickness.

3rd. Next the Lower Lias, also greatly reduced and thinning away towards the Chalk-escarpment. If the Marlstone and Upper Lias were found to exist, it would only be as mere traces, and these would be immediately superimposed by the Upper Zone, or "White Limestones" of the Great Oolite.

A vertical section under Oxford would probably present the following descending series:—

* South Staffordshire Coal-field: Mem. Geol. Survey.

† See Papers in the Edin. Phil. Journal, New Series.

‡ See 'Siluria,' 3rd edit., Appendix.

Formations present.	feet.	Formations absent.	feet.
Oxford Clay	600	Forest Marble (greatest thickness)	150
Cornbrash	5	Great Oolite (Lower Zone)	100
Great Oolite (Upper Zone)	200	Fuller's Earth	200
Lower Lias	200?	Inferior Oolite	270
Red Marl (Keuper)	200?	Sands	150
Lower Permian Beds	?	Upper Lias Clay	400
Coal-measures	?	Marlstone?	240
		Lower Keuper Sandstone	450
		Bunter Sandstone	2150

§ 7. *General Conclusions.*—From the foregoing considerations the following conclusions may be drawn:—

1st. That during the deposition of the Upper Palæozoic and Lower Mesozoic Rocks an extensive tract of land existed to the north-west of the British Isles, which afforded the materials of which these rocks are composed; and it is probable that this region embraced the western isles and coast of Scotland.

2nd. That the Lower Permian Rocks were deposited in a channel, of which we can trace approximately the borders to the west and north-east; and that this group attains its maximum development along a band of country stretching west and east, from the southern borders of Salop, across Staffordshire to Warwickshire.

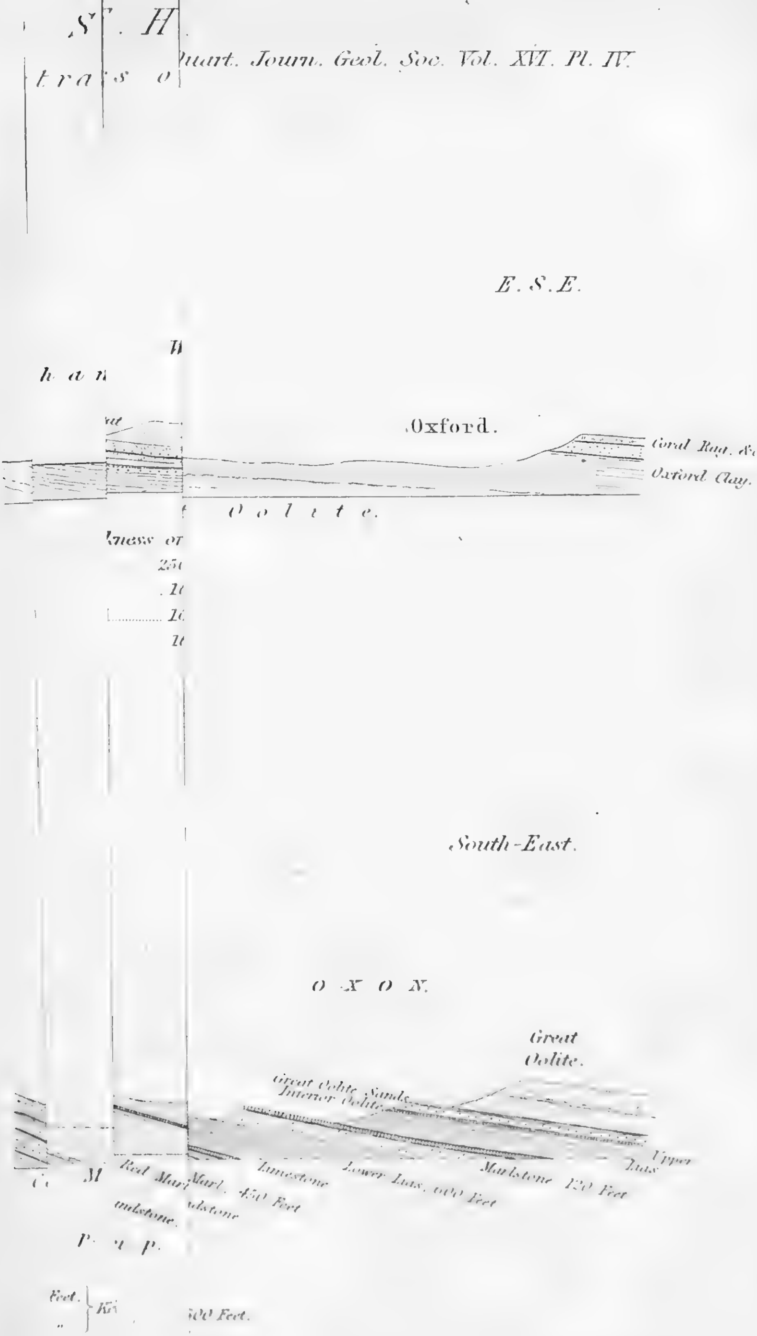
3rd. That at the close of the Permian Period there ensued considerable changes in the distribution of land and sea, involving a large increase in the latter. That a highway was opened between North Wales and Westmoreland, along which the sediment for the formation of the Lower Secondary rocks was transported by an oceanic current and spread over the plains of England, filling up old Palæozoic valleys.

4th. That all the Lower Secondary formations decrease in thickness, and actually die out towards the south-east; that this attenuation is due to the increase of distance from the sources of supply, and the consequent failure of sedimentary materials which have come from land occupying the region of the North Atlantic.

5th. That there probably exists a tract of Coal-measures stretching from the southern borders of the Staffordshire and Warwickshire Coal-fields towards the Thames Valley, as previously surmised by Mr. Godwin-Austen, but that there is reason to fear that the whole formation becomes debased and less likely to contain valuable beds of coal.

6. That the depth to the Coal-measures under parts of Oxfordshire and Northamptonshire cannot, in consequence of the thinning-out of the Lower Secondary Rocks (Inferior Oolite, Lias, and Trias), be considered as beyond the reach of mining enterprise; but that the thickness of the interposed Permian rocks and the economical value of the coal-beds are points of uncertainty, which are likely to be solved only by actual experiment.

Quart. Journ. Geol. Soc. Vol. XVI. Pl. IV.

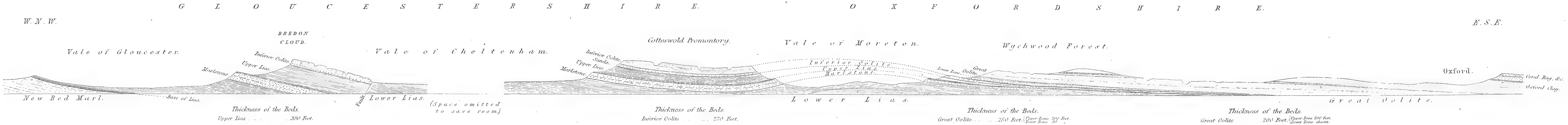


Engraved by J.W. Lowry.

Comparative Sections of the Oolite, Lias, & Trias: by E. Hull, Esq. F.G.S.

To illustrate the South-easterly Attenuation of the Lower Secondary Rocks of England.

Fig. 1.



Thickness of the Beds.

Upper Lias	380 Feet.	
Marlstone	250 „	
Lower Lias	about 700 „	

Thickness of the Beds.

Inferior Oolite	270 Feet.	
Ammonite-Sands	50 „	
Upper Lias	200 „	
Marlstone	150 „	

Thickness of the Beds.

Great Oolite	250 Feet.	Upper Zone 200 Feet. Lower Zone 50 „
Inferior Oolite	10 „	
Upper Lias	10 „	
Marlstone	10 „	

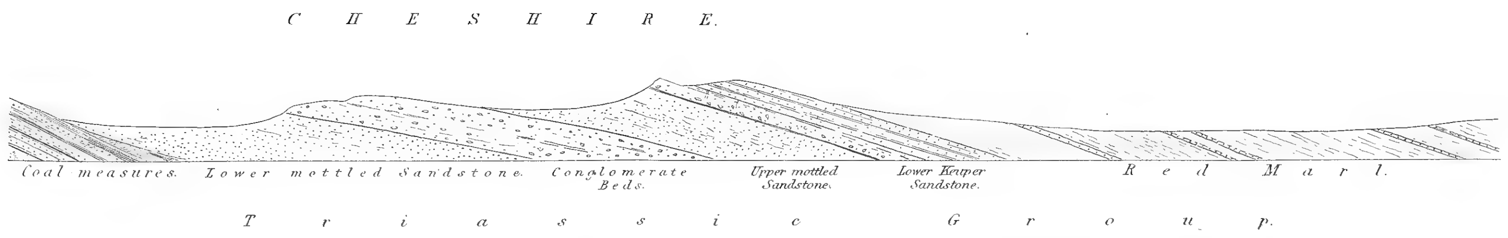
Thickness of the Beds.

Great Oolite	200 Feet.	Upper Zone 200 Feet. Lower Zone absent.
Inferior Oolite	absent	
Upper Lias	absent.	
Marlstone	5 Feet.	

North-West.

South-East.

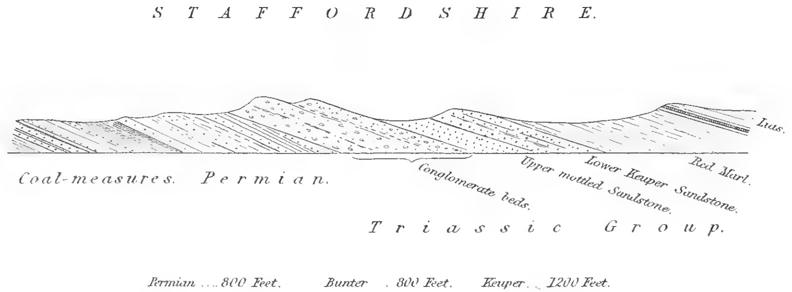
Fig. 2.



Upper mottled Sandstone	700 Feet.	Bunter, 2150 Feet.	Red Marl	about 3000 Feet.	Keuper, 3450 Feet.
Conglomerate beds	750 „		Lower Keuper Sandstone	450 „	
Lower mottled Sandstone	700 „				

(Triassic Group .... 5600 Feet.)

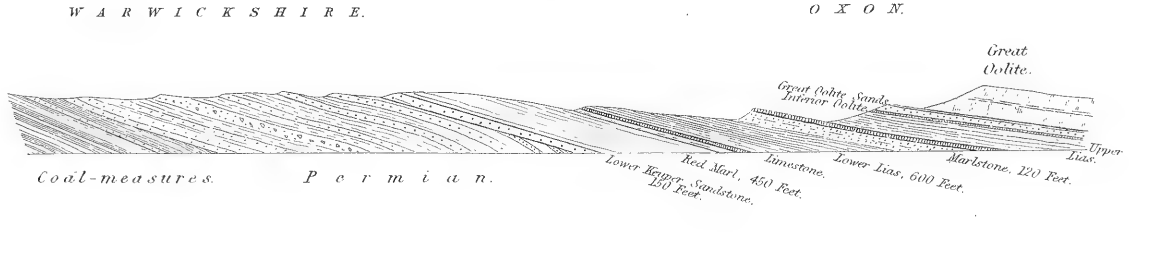
Fig. 3.



Permian ... 800 Feet. Bunter .. 800 Feet. Keuper .. 1200 Feet.

(Triassic Group .... 2000 Feet.)

Fig. 4.



Permian. 1800 Feet. Bunter absent. Keuper .. 600 Feet.

(Triassic Group ...... 600 Feet.)

Engraved by J. W. Lowry.

EXPLANATION OF PLATE IV.

The sections in Plate IV. are intended to illustrate the thinning-out towards the South-east (and, *per contra*, the thickening towards the North-west) of all the formations from the base of the Great Oolite down to that of the Trias. Though founded on actual admeasurement of the strata, the sections are not drawn to any true horizontal scale.

Fig. 1 shows the thinning-away of the Liassic and Oolitic strata, along a line drawn from the banks of the Severn, near its junction with the Avon, across Bredon Hill, the Vale of Cheltenham, the Cotteswold promontory, and Vale of Moreton, to the hills of Coral-rag above Oxford. The line runs W.N.W. and E.S.E. By comparing the thickness of the formations (as given in the figures immediately under the sections) where they are capable of being measured, it will be seen how they all tend to thin away towards Oxford. The whole of the Inferior Oolite is not present on Bredon Cloud, so that its thickness cannot be compared with that of its representative on the Cotteswold Hills; but in the Valley of the Cherwell, near Woodstock, the formatiou has altogether disappeared. The Upper Zone of the Great Oolite, however, evinces no tendency to thin away in any direction.

Figs. 2, 3, and 4 may be considered as one interrupted section, and are to illustrate the same principles in the case of the Triassic rocks. The direction of the section is along a line drawn from the mouth of the Mersey to that of the Thames; and in each the thickness of the formation with its groups is shown as it occurs in Cheshire, Staffordshire, and East Warwickshire. It will be observed that, while the Bunter Sandstone attains in Cheshire and Lancashire the surprising thickness of 2000 feet and upwards, in Staffordshire it has considerably lessened, and dies out before reaching the neighbourhood of Coventry.

The Keuper series in Cheshire is upwards of 3000 feet thick; in Staffordshire it is only 1200; and in East Warwick about 600. The section is continued through the Liassic and Oolitic formations into Oxfordshire.

These sections also show the manner of the distribution of the Lower Permian rocks along the same line of country. This formation becomes more fully developed in Warwickshire than in Staffordshire, and in this latter county more than in Cheshire; proving the remarkable change which ensued at the close of the Palæozoic period in the physical circumstances under which the rocks of the two great epochs were deposited.

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THE

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PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

May 4, 1859.

Matthew Moggridge, Esq., Swansea, Frank Johnstone Mitchell, Esq., Newport, Monmouthshire, and Thomas Wright, M.D., Cheltenham, were elected Fellows.

The following communications were read:—

1. *On the* Ossiferous Grotta di Maccagnone, *near* Palermo. By Dr. H. Falconer, F.R.S., V.P.G.S.

[This communication was made in a letter addressed to Sir C. Lyell, V.P.G.S., and dated Palermo, March 21, 1859. In June Dr. Falconer, having returned home, and his specimens having been examined, read a further and fuller communication on the same subject before the Society on the 22nd of June. By permission of the Council the following abridgement of the Memoir, comprising the information given in the first communication, is here published in place of the Letter.]

[Abstract.]

Dr. Falconer first described the physical geography of that portion of the north coast of Sicily in which the ossiferous caves abound, namely between Termini on the east and Trapani on the west. The geological structure of the tract had been ably investigated and mapped by Hoffmann. A great mass of Hippurite-limestone stretches from Termini to the eastern side of the Bay of Castellamare, which on the side towards Termini forms rugged precipitous or scarped cliffs skirting the sea-shore. From Cape Zaffarana to Capo di Gallo, a distance of about twenty miles, the coast-line is

deeply indented by the Bay of Palermo; west of Capo di Gallo there is a smaller indentation, backed by Carini; and still further to the west there is the deep Gulf of Castellamare. At the bottom of these indentations the mountains of Hippurite-limestone recede from the coast, forming inland precipitous cliffs or rugged slopes, from the base of which stretch slightly inclined flats of marine Pliocene deposits, which disappear under the sea. These latter form nearly horizontal strata of a calcareo-argillaceous sandy breccia, full of marine shells and fragments of corals, &c. Philippi identified 209 species of Mollusca from this deposit in the neighbourhood of Palermo, the great majority being of living species. The ossiferous caves had been known from remote antiquity, and notices of them occur in Valguarnera, Il Mongitore, and other Sicilian historians. The botanist Cupani had figured and identified some of the bones. The author's investigations had been directed to the caverns near Palermo and Carini. At Palermo the littoral pliocene plain, celebrated for its richness as the "Concha d'Oro," or shell of gold, is from a mile to 1½ mile broad, and where it abuts against the Hippurite-rocks is from 180 to 200 feet above the level of the sea. The ancient Pliocene sea-margin is very distinctly seen at this elevation all round the bay, and the ossiferous caverns chiefly occur at from 30 to 50 feet above this level. Some of them, such as the "Grotta di Belliemi," are at a higher level. The caves are studded all round the bay. The Hippurite-limestone hills skirting the coast are here from 1200 to 1800 feet above the sea; some of the heights more inland, such as Monte Griffone and Monte Cuccio, attain a height of upwards of 3000 feet.

The best-known of the caves is the "Grotta di San Ciro," or "Mare Dolce," at the foot of Monte Griffone, about two miles from Palermo, and 50 feet above the pliocene terrace. This cave had been described by the Abbé Scinà in a special report, and after him by Turnbull-Christie and by Hoffmann. It is about 130 feet long, 50 feet high, and 30 feet wide in the middle. The cave had been hollowed out into a well-marked, irregular, basin-shaped depression near the mouth, where obscurely stratified and other deposits occur to a depth of 30 feet in the aggregate. On the bottom was found a thin layer of sand, in which Philippi detected 44 species of 23 genera of marine Mollusca. Above this there is an enormous mass of bone-breccia, consisting of closely-crammed bones, cemented into a hard rock by an argillaceo-calcareous concrete matrix, and forming a thickness of 20 feet; above this a stratum of stones and bones, more sparingly mixed and similarly cemented, to a depth of 2 or 3 feet; then a layer of "Lastroni," or blocks of limestone, to a depth of 6 feet; and above all a layer of ochreous earth and rock-splinters to a depth of 1 foot. The bones in this breccia are mineralized by calcareous infiltration. The interior and back part of the cavern was covered by a layer of light and incoherent argillaceous soil, containing an enormous quantity of bones, chiefly of *Hippopotami*, nearly devoid of gelatine, and in the ordinary friable condition of grave-bones. The relations of this deposit were never accurately observed,

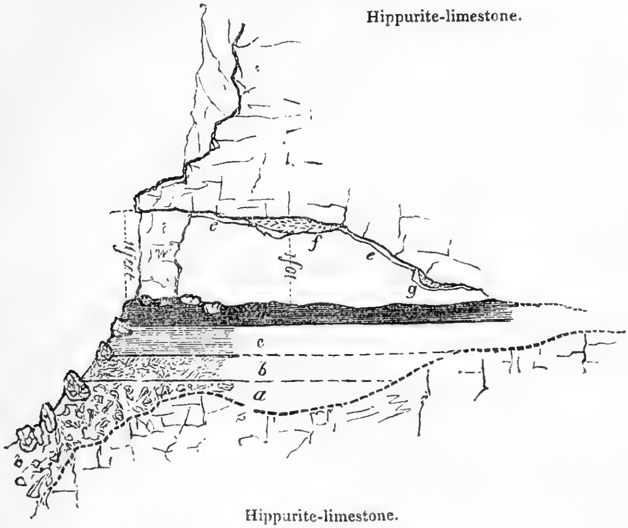
in consequence of the rubbish of the excavation-operations having been thrown up in a great mass of talus extending backwards to near the roof of the cavern.

In 1829 there was a great demand for bones for the manufacture of lamp-black for sugar-refining. The superficial bones of the San Ciro cavern were collected in large quantities and exported to England and Marseilles. Professor Ferrara states, that within the first six months 400 quintals were procured from San Ciro. The great majority belonged to two species of *Hippopotamus*. In one heap, out of several shiploads sent to Marseilles, De Christol, an able palæontologist, had found that in a weight of 30 quintals all the bones belonged to *Hippopotamus*, with the exception of six derived from *Bos* and *Cervus*. Dr. Falconer had examined in detail the San Ciro collection in the University of Palermo, and found, as a general rule, that *Hippopotamus* bones preponderated in a similar proportion. De Christol had counted about 300 astragali alone of this genus; and Abbé Scinà had collected, for the Museum of Palermo, 76 astragali of *Hippopotamus*, 40 of which belonged to the right side and 36 to the left. The bone-breccia is chiefly composed of bones of *Hippopotamus*, and extends on either side outside the cave to a length of about 85 yards. Assuming the above ratio of astragali to the other bones as a standard for an approximative estimate of the number of the skeletons inside and outside the cavern, the author showed what a vast number of individuals it implied. He considered that they were accumulations of a long series of generations. A lively discussion having arisen in Sicily as to the origin of these bones, in which Ferrara maintained the opinion that they consisted of the skeletons of Elephants captured by Metellus from Hasdrubal 504 years before the Christian era, and of *Hippopotami* imported by the Saracen rulers of Sicily during the Middle Ages, the government undertook an exploration of the cavern. A deep trench was dug longitudinally into the cavern; and the bone-breccia was quarried out, along a considerable extent, down to the floor of the cavern. Some very interesting phenomena were disclosed. The eastern wall (left, on entering) was found to be smoothly polished to a height of 18 feet, the lower 8 feet of which formed a band thickly drilled with Pholad-borings. The holes were filled with matrix of the bone-breccia, and they were greatly reduced in depth by the grinding action which had produced the polished surface. The opposite wall of the cavern was equally polished to the same height, but free from borings. The walls above the polished band, and the roof, were rugged and cancellar, with but a very sparing exhibition of stalagmite on the latter. The author had identified from San Ciro two species of *Hippopotamus*, *Elephas antiquus*, *Sus*, *Bos*, *Cervus*, *Ursus*, *Canis*, and a large species of *Felis*. *Elephas antiquus* elsewhere indicates the newer Pliocene age.

Another cave, hitherto undescribed, called the "Grotta di Maccagnone," about a mile to the westward of Carini, was lately the special subject of the author's research. It is nowhere noticed by the Sicilian historians. Dr. Falconer's attention had been directed

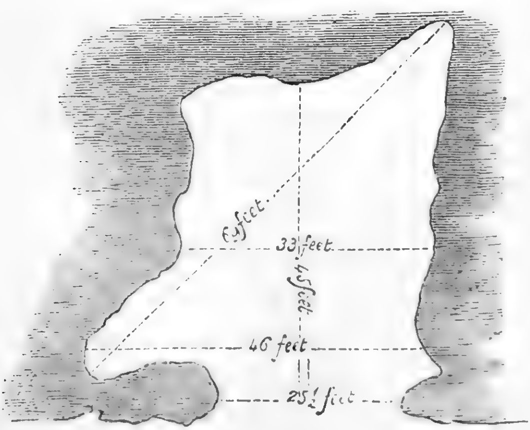
in that quarter by J. Morrison, Esq., a resident merchant of Palermo, who had many years ago procured fossil bones from the neighbourhood of Carini, which are now displayed in the Museum of the College of Surgeons. The author was under great obligations to the kind services, scientific aid, and hospitable cares of Baron Francesco Anca (di Mangalaviti) and Professor Angelo Porcari, of the University of Palermo, who accompanied him in all his visits to Carini, and cooperated with him in the excavations carried on in and near the Maccagnone Cave. Their assistance applied to every walk of the exploration. The cave is situated on the north-eastern side of Monte Lungo, near its base, and about a mile and a half from the sea. Like San Ciro, the Maccagnone Cave is about 50 feet above the termination of the pliocene marine terrace where it abuts against the Hippurite-limestone, and at a corresponding elevation above the sea; both caves partaking in many respects of common physical characters. But in its form, and some of its deposits, the Maccagnone Cavern differs materially from San Ciro. It is much broader and more sinuous at the sides than San Ciro, with several large *cul-de-sac* expansions; but not so long; and the roof is much lower, being but 11 feet high at the principal entrance, and about 10 feet in the middle. There are two entrances, the principal of which is 25½ feet wide, and open down to the floor: the other, on the same side of the hill, is a much smaller, irregular aperture, in connexion with an irregular expansion of the cavern at its south-eastern corner, into which it descends. The author gave the principal dimensions, which were accompanied by a ground-plan and section (figs. 1 & 2). The uppermost layer of the floor consists throughout of loose, argillaceous, finely pulverized soil, containing large imbedded blocks of limestone; beneath this, in the section below the mouth, was a thick deposit of the ochreous loamy earth (called "Cave-earth"), containing blocks of limestone; then, in thick patches, a reddish-grey and mottled spongy loam, cemented by calcareous infiltration, and very cellular, called from its appearance, by the peasants who were employed on the excavation, "*Ceneri impastate,*" or "concrete of ashes;" and below all, stretching on either side of the mouth, as at San Ciro, a great aggregation of bone-breccia, full of bones of *Hippopotamus*, among which the author in four days collected a very large number of astragali. The whole of the bone-breccia was strewed over with huge blocks of limestone which had fallen since its deposition. Nothing is known of the nature of the inferior deposits down to the floor. The author thinks it probable that there may be a great accumulation of bone-breccia below, with polished and bored walls, as in San Ciro; but the excavations requisite to establish this were too laborious and extensive for the limited time at his disposal. The interior of the cavern is coated over throughout by a crust of rough, reddish or ochreous stalagmite. The surface-layer of the floor had been previously dug for fossil bones as far back as 1830, and but few remains were found in it. One—an important specimen—was a milk-molar of *Elephas antiquus*. At the side below the southern wall of the cavern, and about halfway in, a thick layer was observed of

Fig. 1.—*Vertical Section of the Grotta di Maccagnone.*



g. Roof-breccia in the back of the cavern, coated with stalagmite.
f. Roof-breccia cemented to the ceiling.
e. Stalagmite coating the ceiling of the cave.
d. Humatile layer, with blocks of limestone.
c. Yellow ochreous bed, or "cave-earth," with blocks.
b. Grey cancellar deposit.
a. Bone-breccia, with blocks of limestone.
w. Wall of the entrance.

Fig. 2.—*Ground-plan of the Grotta di Maccagnone.*



the "Ceneri impastate" immediately below the superficial earth, and corresponding exactly with the "Ceneri impastate" seen in the section outside below the principal aperture. The attempts at making a section of the floor were frustrated by the great blocks of limestone, which impeded the operations throughout. In the superficial layer, besides *Elephas antiquus*, horns of two extinct species of *Cervus* were found, besides other bones of Ruminants, but all in small quantity: in the ochreous cave-earth below the mouth, abundant coprolites of *Hyæna*, with fragments of detached bones of *Hippopotamus*, and some astragali: in the "Ceneri impastate" below the main aperture, metacarpal and metatarsal bones of a species of *Felis* as large as *F. spelæa*, but not yet specifically identified; some remains of a large *Ursus*, and numerous remains of small Ruminants, all broken or splintered, but none of them bearing marks of gnawing. In the "bone-breccia" below and outside the cavern, the bones of *Hippopotami* very largely predominated. The author dug up an enormous quantity of these remains within an area of 12 or 14 feet square. In an angular recess in the rock outside the cave, and near the small opening, a very large quantity of coprolites of Hyænas were observed, superficially imbedded in the "ochreous earth." The quantity collected together would indicate that this spot had been used as a common cloaca of Hyænas.

The author next described some remarkable conditions in the roof of the cave. About halfway in from the mouth (fig. 1, *f*) and at 10 feet above the floor, a large mass of breccia was observed, denuded partly of the stalagmitic covering, and composed of a reddish-grey argillaceous matrix cemented by a calcareous paste, containing fragments of limestone, finely preserved entire land-shells of large size, splinters of bone, teeth of Ruminants and of the genus *Equus*, together with comminuted fragments of shells, bits of carbon, specks of argillaceous matter resembling burnt clay, also fragments of shaped siliceous objects, of different tints, varying from the milky or smoky colour of chalcedony to that of jaspery hornstone. This brecciated matrix was firmly attached to the roof, and for the most part covered over with a coat of stalagmite. In the S.S.E. expansion of the cavern near the smaller aperture, a considerable quantity of coprolites of *Hyænæ* was found similarly situated, in an ochreo-calcareous matrix, adhering to the roof, mingled with some bits of carbon, but without shells or bone-splinters. In the back part of the cavern, where the roof shelves towards the floor, thick masses of reddish calcareous matrix were found attached to the roof, and completely covered over by a crust of ochreous stalagmite (fig. 1, *g*). It contained numerous fragments of the siliceous objects mixed with bone-splinters and bits of carbon. In fact, all round the cavern, wherever the stalagmitic crust on the roof was broken through, more or less of the same appearances were presented. In some parts the matrix closely resembled the character of the "Ceneri impastate" with a larger admixture of calcareous paste.

With regard to the fragments of the siliceous objects, the great majority of them present definite forms, namely long, narrow, and

thin; having invariably a conchoidal smooth surface below, and above a longitudinal ridge, bevelled off right and left, or the ridge replaced by a concave facet, in the latter case presenting three facets on the upper side. The author is of opinion that they closely resemble, in every detail of form, obsidian knives from Mexico, and flint knives from Stonehenge, Arabia, and elsewhere, and that they appear to have been formed, by the dislamination, as films, of the long angles of prismatic blocks of stone. These fragments occur, intimately intermixed with the bone-splinters, shells, &c., in the roof-breccia, in very considerable abundance; other amorphous fragments of flint are comparatively rare, and no pebbles or blocks occur either within or without the cave; but similar reddish flint or chert is found in the Hippurite-limestone near Termini.

In regard to the theory of the various conditions observed in the Maccagnone Cave, the author considers that it has undergone several changes of level, and that the accumulation of bone-breccia below and outside is referable to a period when the cave was scarcely above the level of the sea. Dr. Falconer pointed out the significance of the fact that, although Hyæna-coprolites were so abundant against the roof and outside, none, or but very few, of the bones of Hyænas were observed in the interior; he remarked also on the absence of the remains of small mammalia, such as Rodents. He inferred that the cave in its present form, and with its present floor, had not been tenanted by these animals. The vast number of *Hippopotami* implied that the physical condition of the country must have been greatly different, at no very distant geological period, from what obtains now. He considered that all deposits *above* the bone-breccia had been accumulated up to the roof by materials washed in from above, through sinuous crevices or flues in the limestone, and that the uppermost layer, consisting of the breccia of shells, bone-splinters, siliceous objects, burnt clay, bits of charcoal, and Hyæna-coprolites, had been cemented to the roof by stalagmitic infiltration. The entire condition of the large fragile *Helices* proved that the effect had been produced by the tranquil agency of water, as distinct from any tumultuous action. There was nothing to indicate that the different objects in the *roof-breccia were other than of contemporaneous origin*: subsequently a great physical alteration in the contour, altering the flow of superficial water and of the subterranean springs, changed all the conditions previously existing, and emptied out the whole of the loose incoherent contents, leaving only the portions agglutinated to the roof. The wreck of these ejecta was visible in the patches of "Ceneri impastate," containing fossil bones, below the mouth of the cavern. That a long period must have operated in the extinction of the Hyæna, Cave-lion, and other fossil species, is certain; but no index remains for its measurement. The author would call the careful attention of cautious geologists to the inferences:—That the Maccagnone Cave was filled up to the roof within the human period, so that a thick layer of bone-splinters, teeth, land-shells, Hyænas' coprolites, and human objects was agglutinated to the roof by the infiltration of water holding lime in solu-

tion. That subsequently, and within the human period, such a great amount of change took place in the physical configuration of the district as to have caused the cave to be washed out and emptied of its contents, excepting the patches of material cemented to the roof and since coated with additional stalagmite.

List of Fossil Shells found in the "Grotta di Maccagnone," as determined by Padre Lebassi, Curator of the Museum of the "Collegio Massimo dei Gesuiti" in Palermo, 18th March, 1859.

	Where found.	Remarks.	Remarks by Padre Lebassi.
1. Helix Mazulii	Roof-matrix, back part of cave.	A solitary shell, partly broken.	Very rare in Sicily in the fossil state.
2. Helix aperta (Born.) (H. naticoides, Drap.) ...	Roof-matrix.	....	Very abundant in the living state: like *H. Mazulii.*
3. Helix vermiculata	Roof-matrix.	Very abundant: shells in perfect integrity.	Very common in the living state: rare fossil.
4. Helix cellaria (Müller) ...	Roof-matrix.	....	Very common in living state: not observed fossil by Philippi.
5. Trochus fragaroides (Lam).	....	....	Very common: living.
6. Patella ferruginea (Linn.)..	....	A solitary specimen.	Very rare in the sea around Sicily: very common fossil.

Note.—The author has lately received a letter from Baron Anca di Mangalaviti, dated Palermo, the 12th of March, intimating that he had followed up the Cave-researches which form the subject of this communication, with important results. He had discovered two caves, hitherto unknown to naturalists,—the one in Monte Gallo, which forms the western boundary of the Bay of Palermo; the other in the north of Sicily, at the foot of Monte San Fratello, near the village of Acque Dolci. In both caverns, but more especially in the latter, Baron Anca found an immense accumulation of fossil bones, among which there was "une prodigieuse quantité d'os des Carnivores." This is the more remarkable, as in the Caves of San Ciro and Maccagnone *Carnivora* were but very sparingly encountered.

With regard to the flint objects discovered in the Maccagnone Cave, he adds,—

"J'ai également rencontré dans les deux grottes une grande quantité *de Silex en armes*, lesquels, chose remarquable, on ne voit généralement que là où il y a des grands dépôts d'ossements de cerfs, et jamais ailleurs. Enfin des Coprolites des Carnivores, et une autre espèce de Coprolite, que je suppose appartenir à des animaux herbivores."

The further development of Baron Anca's researches will, in all probability, throw much light on the subjects discussed in this communication.—H. F., 5th April, 1860.

2. *On some* Fossil Reptilian Eggs *from the* Great Oolite *of* Cirencester. By Professor J. Buckman, F.G.S., F.S.A., F.L.S., &c.

The fossils which form the subject of this notice, were obtained by one of my pupils (Mr. Dalton), from the Hare-Bushes Quarry, about one mile to the east of Cirencester.

This quarry, which is largely worked for the use of its freestone, offers a good section of the upper beds of the Great Oolite of Gloucestershire,—the alternations of their bands of stone and partings of clay marking that unsteadiness of character by which the Bradford Clay and the Forest-marble appear to have commenced their depositions, the Bradford Clay (that is, a marly bed containing the fossils originally observed at Bradford, such as the *Apiocrinus rotundus*, *Terebratula digona*, *T. coarctata*, and *T. cardium*) being only local, but still observable in many positions both to the east and west of the Hare-bushes—the most remarkable being at the Acman-street or Tetbury-road Station, about two miles to the west of the Royal Agricultural College, where the bed is about eight feet thick in its deepest part, and whence Mr. Woodward obtained no less than 127 species of fossils.

Where, however, the bluer clays set in, marking the true Forest-marble, these will be found to contain but few fossils; at the same time, their position is well marked by their always resting on the upper, obliquely laminated, bed of the Great or Bath Oolite, as shown in the following

Section of the Hare-Bushes Quarry.

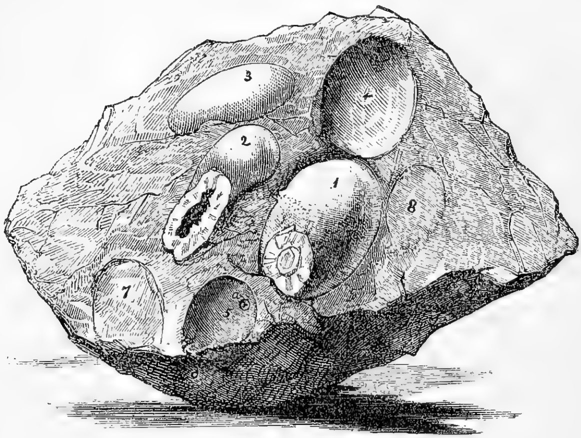
		ft.	in.
	1. Surface-Soil (brashy)	1	0
Forest-marble.	2. Thin bands of freestone, separated by marly partings, blue and yellow	5	0
	3. A white freestone, with oblique bedding, very decidedly oolitic	8	0
	4. A very white or cream-coloured freestone, in rough nodular blocks	2	0
	5. Beds of freestone in blocks (equivalent to the Bath building-stone) in which oblique lamination is usually only visible after long exposure (bottom of quarry)	10	0
		26	0

The specimen containing the fossil eggs (see Figs. 1 and 2) was found in the stage marked 4, and consists of the characteristic stone. It is, however, to be regretted that, from not having myself taken it from the quarry, I can form no conclusion as to the manner in which the eggs originally lay in the bed, though I should almost think they formed the upper part of the specimen.

There can be no doubt, however, as regards the general nature of this portion of the Oolitic deposit, that it was accumulated on a widely shelving beach, or in a very shallow sea, as the oblique lami-

nation of the rock, the occasional pseudo-ripple-marks which the strata present, and the abundant fragments of fossil wood which are included in most of the blocks of stone, amply testify.

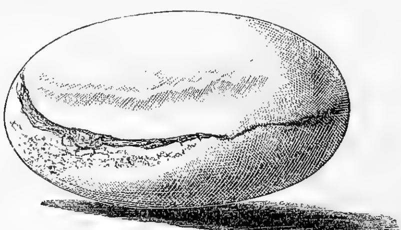
Fig. 1.—*Block of Oolite, with an imbedded group of Eggs, of which eight are seen.* Reduced ½.



1. Egg filled with crystals of carbonate of lime.
2. Egg, having the interior lined with crystals of carbonate of lime. This egg has been laterally squeezed, especially towards one end.
3. Egg partly exposed.
4. Cavity left by another egg, which has been removed, and is figured separately (fig. 2).
5. Hollow left by the removal of a specimen; at *a* a small, round, concentrically marked, low conical patch of carbonate of lime remains.

6, 7, & 8. Indications of other eggs.

Fig. 2.—*One of the Eggs, of the natural size.*



The specimen is filled with crystallized carbonate of lime, and is fractured along its greatest diameter: and the surface exhibits a slight ridge that has been occasioned by pressure when the egg was flexible.

As regards the specimen itself, it may be described as a cluster of the remains of at least eight eggs, of a uniformly ovate, not ovoid

shape. A specimen freed from the matrix (fig. 2) has the following proportions:—

	inches.
Length	$1\frac{3}{4}$
Breadth	$1\frac{1}{10}$
Circumference of its long axis	$4\frac{1}{2}$
Circumference of its short axis	$3\frac{4}{10}$

The separated example, as well as some of the imbedded eggs, is more or less filled with transparent crystals of carbonate of lime. The shells of all (if they were originally of calcareous matter) appear to have been very thin, as some of the eggs are distorted by compression in such a manner as seems to bear evidence of a large amount of flexibility: there are no decided traces of fracture, though some of the individuals are greatly flexured.

From their clustered grouping we may, I think, conclude that they form but a part of a larger collection which were deposited in the calcareous sand of the shallow waters of the Oolitic sea; and, from the circumstances of the abundant presence of the following shells in blocks of the surrounding Oolite, notwithstanding the occurrence of bits of wood, as these always bear traces of having been drifted, the conditions were entirely those of a marine character:—

Cardium Buckmanni, and another.
Lima cardiiformis.
Pecten lens.
Pecten lamellosus, and others.
Ostrea jurassica.
Terebratula maxillata.

In commenting upon the nature of the creature by which these eggs were deposited, we shall find that the subject is so new, and these specimens indeed are so unique, that as yet, from the paucity of evidence, remarks upon this subject can be little more than conjectural. We have, however, organic remains now before us, of the same age, and from the same district, which point to the existence of Chelonian and Saurian Reptiles in these Oolitic beds.

Dermal scutes of Turtles have been obtained from the Bradford Clay of the Tetbury Road Station, which, if present at the Harebushes, would occupy a position upon bed No. 3 of our section. But we may discard the notion of the eggs having belonged to a Turtle, since, though the ends of these examples are bluntly rounded, yet the proportions will show that they are far removed from the spherical shape which characterizes the eggs of this class of reptiles. There is, then, more probability of these fossil eggs having belonged to one of the Saurian creatures, the remains of which are not uncommon throughout the Oolites; but, upon the supposition that the *Ichthyosaurus* and *Plesiosaurus* were true oviparous reptiles, I should conclude that the eggs in question were too small to have been deposited by any of the Enaliosaurian species the remains of which I have as yet detected in the Great Oolite.

It has been suggested that the eggs may have been those of a Teleosaurian Reptile; and it may be so, since remains of *Teleosaurus* have been found in the Stonesfield Slate, at the bottom of the Bath Oolite, and in the Bradford Clay at the top, and since, in all probability, some of the fragmentary reptilian bones so often occurring in

the Great Oolite may belong to the same form of reptile,—the size of the eggs being such as I could conceive might have belonged to one of these creatures. At the same time it must be confessed that, as yet, direct evidence is wanting upon the matter; I must therefore at present content myself with having described the conditions under which the subject of the present memoir was found, regretting that, as its discovery is due to a pupil (the late Mr. Dalton) who has since died, I cannot be so minute upon this point as I could wish. I am keeping, however, a sharp look-out in the Oolites of my own neighbourhood for additional specimens, and I hope the publication of these remarks may cause others to do the like.

I venture to propose for this specimen the provisional name of *Oolithes Bathonicæ*.

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3. *Some Observations on the* Flora *of the* Oolite.
By Baron Achille de Zigno.

[Communicated by C. J. F. Bunbury, Esq., F.R.S., F.G.S.]

In presenting to the Geological Society of London the Second Part of my 'Flora of the Oolite,' I wish to submit to the Society some explanations and some observations on the work I have undertaken.

The comparative study of the numerous materials discovered in the beds subjacent to the Oxfordian group of the Venetian Alps has rendered it necessary to pass in revision all the species belonging to the Oolite that are at present known.

Although I am quite aware of the difficulty of the task which I have imposed on myself, and of the numerous imperfections which must be inevitable in a general work of this nature, in the present state of our information on this subject, still I have not hesitated to undertake it, encouraged as I am by the hope, that in any case it may be of some use to those who would wish to undertake the study of the Flora of the Oolite.

The publication of the generalizations which are usually placed at the beginning of a work has been purposely postponed by me, in order that I might profit by new discoveries, and thus present as complete a view of the subject as possible.

The sketch of these generalizations (from vol. vi. of the 'Memoirs of the Imperial and Royal Institute of Venice') which I had the honour of presenting to the Society last year, will undoubtedly be perceptibly modified by the new facts which may hereafter enrich science. I accordingly published in 1856 a short review of facts on the geographical extent, on the geological distribution, and on the analogies of the flora of the Oolite with those of the Keuper, of the Lias, and of the Wealden group, in order to excite the men of science who live in those geological districts to the publication of materials which have not yet been made known, or at any rate to induce them to communicate such corrections as their information may lead them to consider necessary, and which will thus be brought to bear upon science.

In the memoir 'On the Flora of the Oolite,' of which I have been speaking, I have passed in review the different localities of the globe where vegetable remains have been found in Oolitic beds. In this enumeration it will be seen that I cite the phytolitiferous deposits of Scania, those of Richmond in America, as well as those of India and of Australia. But these deposits still require detailed study as regards their stratigraphical position and their paleontology before they can be placed definitely in the Oolite; and we also want positive and detailed information on the beds with Cycadaceæ and Ferns in South Africa, mentioned at the meeting of the British Association in 1851 as discovered by Dr. R. N. Rubidge.

It is well known how the deposits of Scania have been by turn placed in the Lias by Brongniart, Hisinger, and Braun, in the Wealden group by Mantell, and in the Oolite by Nilsson and Forchhammer. I am inclined to think that in Scania there may be two phytolitiferous beds,—the lower one containing plants of the Lias, the other contemporary with the lower Oolite group. As to the analogies which may exist between one part of their flora and that of the Wealden group, I have already pointed out the existence of these analogies among the floras included between the Keuper and the Neocomian formation. (See the memoir above quoted.)

As regards the beds of Richmond in America, it seems that the materials recently discovered would authorize us to exclude them from the Oolite.

I had begun to occupy myself in my 'Flora' with the fossil plants of Richmond, when, after the printing of the eighth sheet of the text, I saw it announced in the 'Neues Jahrbuch' of Leonhard and Bronn, that the specimens of plants found in this locality by Dr. Emmons, and examined by Professor Heer, present the characters of a more ancient flora, and that Sir Charles Lyell, after inspecting some specimens brought by M. Jules Marcou, is inclined at present to place them as low as the Trias. If these last observations are confirmed, the plants of Richmond would be naturally excluded from my 'Flora.'

The Indian strata with fossil plants, where species have been found identical with those of Yorkshire*, may be placed, I think (if not with certainty, at least with much probability, particularly after the investigations of Messrs. Hislop and Hunter), in the lower group of the Oolite.

This would not be the case with those of Australia, if the observations made in 1847 by the Rev. Mr. Clarke were confirmed; for he mentions in these deposits the presence of the genera *Sigillaria*, *Lepidodendron*, and *Stigmaria*, which would settle the question. But I am not aware that the facts thus cited have been since verified. On the contrary, no mention is made of these genera in the works of Messrs. Morris and M'Coy, in which we are presented with a series of forms among which, together with local types analogous to those of India, there are species which recall the Jurassic flora of Scarborough.

* See Mr. Bunbury's Note in the Appendix.

The conscientious labours of these two last-mentioned men of science have made me decide to include these localities in the geographical range of the flora of the Oolite.

Some of these forms are represented in the part of my work that I have now the honour to present to the Society, which contains almost all the *Calamites* of the Oolite ranged according to the classification lately adopted by Dr. Ettingshausen, who, after observations on a great number of well-preserved specimens, has united the *Asterophyllites* to the *Calamites*. To avoid the multiplication of names, I have left provisionally the *Vertebraria* and *Trizygia* of Forbes Royle in the genus *Sphenophyllum*; at least I thought it better to do so, until more developed specimens should unveil to us the real nature of these vegetable forms.

The characters deduced from the sheath, the border of which is divided into strips, or foliaceous appendages, have made me refer to the genus *Phyllotheca* two new forms, belonging to the Oolite of the Venetian Alps, figures of which will be found in plates 7 and 8 of the second Part of my work, which these notes accompany. Lastly, this second Part also contains the description of two new *Equiseta* from the same locality, the figures of which have appeared in the first Part. As to the description of the objects represented in plates 9, 10, 11, and 12, it will appear in the following Parts of my work. In the meanwhile I request English palæophytologists to give their attention to these plates.

The reniform leaf (plate 9. fig. 2), with its principal veins twice-forked, and its secondary veins anastomosing, presents the greatest analogy to the sterile fronds of the recent *Platycerium*. The only fossil genus which has any resemblance to this figure is the genus *Protorhipis* of Dr. Andrae *, founded upon these same analogies.

The figures 3, 4, & 5 of the same plate (9) present other forms, which will undoubtedly interest English men of science on account of their resemblance to the *Tympanophora* of Messrs. Lindley and Hutton, which M. Pomel has wrongly placed among the *Algæ*, and which is certainly a Fern. These specimens, found in the mountains of our neighbourhood, now confirm the fact which has been already stated by Messrs. Bean and Bunbury. My figures show, in the lower part of the leaf, traces of the foliaceous expansion of the pinnules, and present characters which induce me to consider this specimen as belonging to the group of *Hymenophylleæ*.

Plate 10 represents two specimens of a plant belonging to the *Gleicheniaceæ*, to which I have hitherto seen nothing analogous among the plants of the Oolite, unless the bad specimen of the *Pecopteris Desnoyersii* of Brongniart, found in the Oolite of Mamers, may be considered related to this family.

Plate 11 gives figures of some remains which I do not hesitate to refer to *Odontopteris*.

The genus figured in plate 12 contains species which appear intimately allied to, if not identical with, the *Thinnfeldia* of Ettings-

* Beitr. zur Kenntniss der foss. Flora Siebenbürgens und des Banates. Abhandl. d. K. K. Geologisch. Reichsanstalt, vol. ii. part 3. art. 4. p. 36, tab. 8. fig. 1.

hausen, and to the *Pachypteris* of Brongniart. M. Andrae, in the work cited above, has already referred the *Thinnfeldia* to *Pachypteris*, pointing out that the *Sphenopteris lanceolata* and the *Neuropteris lævigata* of Phillips, cited by Brongniart as synonyms, have flabellate veins, and want the character which Brongniart particularly mentions, that is to say, pinnules with one single midrib. It now remains to find out whether in the Yorkshire beds there exist true *Pachypterides* with this last character, which I doubt, but which can only be ascertained by the geologists of England.

In the last place, I venture further to detain the Society by directing its attention to another plant, of which I shall give the analysis in the third Part of my 'Flora.' It is the *Equisetites columnaris*, which many authors have pointed out as being a species common to the beds of the Keuper, the Lias, and the Oolite. This wide range has hitherto not been disputed in any positive manner, although Sternberg and Bronn have remarked that probably different species were intended. The character of the swelling of the articulations, pointed out by König, is clearly seen in all the figures which accompany Sir Roderick Murchison's memoir on Brora, as well as in that of the work of Young and Bird; while this swelling does not exist in the specimens which are procured from other formations. M. Brongniart, after saying that the sheaths are closely pressed to the stem, and thus cause the appearance of a swelling, denies the existence of those swellings pointed out by König. But the figures given by Brongniart, in his 'History of Fossil Plants,' of specimens received from Yorkshire, represent impressions pretty well preserved, and show that these swellings exist, and are certainly not owing to the sheaths, the delicate tissue of which could not have caused these impressions, especially as they were, according to Brongniart, *cauli arcte applicatæ*. Moreover the figures in the memoir of Sir Roderick Murchison, and those in the work of Young and Bird, present to us portions of denuded stems without sheaths, the articulations of which are decidedly swollen, so much so as to cause a considerable increase of the diameter of the stem in that point.

I take the liberty of calling the attention of the Society to these facts; for, after having compared these figures with specimens of the *Equisetites columnaris* from the Continent, I am inclined to admit that the plant illustrated by König is very different from this latter. If an examination of the specimens from Brora and from Yorkshire confirm what I have just stated, I propose to give this species the name of *Equisetites Kœnigii*.

The materials found in the Oolite of the Venetian Alps give me the opportunity of communicating some observations upon a plant hitherto referred to the genus *Glossopteris*, that is to say, the *Glossopteris Browniana* of Brongniart from the Oolitic (?) beds of India and Australia.

In different localities of the Upper Veronese, I have found isolated leaves, having, by their form and their venation, a striking resemblance to the figures of this species given by Brongniart. But close to these specimens I have observed others composed of four leaves (similar in

all respects to those which are isolated) united together on a very long common leaf-stalk, and forming thus a digitate frond, as in the *Sagenopteris*.

The two middle leaves are obovate-spathulate, like those of *Glossopteris Browniana*, while the lateral leaves are ovate-lanceolate and a little oblique. The largest leaves which I have found in our neighbourhood are middle leaves, having a length of 11 centimètres, and a diameter (in the broadest part, which is towards the extremity) of 4 centimètres and a half. The specimens from Italy, like those of India and Australia (although I am not yet certain of the identity of the species), have precisely the same disposition of the veins (all of equal size) as the *Sagenopteris*, which also has been observed by Mr. Morris in specimens from New South Wales. (See Strzelecki's 'Physical Description of New South Wales and Van Diemen's Land,' p. 247.)

Mr. Bunbury, to whom I have communicated these observations, is inclined to agree with me on the point. He has also recognized in specimens of the *Glossopteris* of India the venation belonging to the *Sagenopteris*; and, in his answer to my letter, he announces to me that the *Glossopteris* from the Indian strata has been lately found with a frond digitated in the same manner as that of *Sagenopteris* *. It remains to be ascertained whether the fructification of the *Sagenopteris* is like that of the *Glossopteris*, such as Brongniart and Goeppert have represented it in their plates. Some scattered dots on the fronds of the Venetian specimens lead me to suspect it; but these are too rare, and too slightly indicated, to authorize one to consider them with any certainty as traces of fructification.

The Oolitic beds of the Venetian Alps contain a great many remains of Ferns, but the number of species is as yet very restricted. Among these the forms are most of them new. The preservation of the specimens is surprising, and some of them show fructification in the most evident manner. Simple immersion in water saturated with nitric acid is sometimes sufficient to separate the epidermis of the two surfaces of the pinnules, and thus to observe the tissue easily through a microscope. The abundance of *Cycadeæ* surpasses that of Ferns; there are a greater variety of species, and several of these species seem nearly allied in form to those found in Yorkshire. The *Coniferæ*, though pretty numerous, do not present many species. The *Brachyphylla* are the most common. Some very long leaves, with parallel veins and amplexicaul base, present the characters of the *Poacites*, which Brongniart has now placed in his new genus *Pychnophyllum*; and they seem to me to indicate, together with the allied forms of *Glossopteris Browniana* (of which I have just been speaking) and those that I refer to *Phyllotheca*, a certain relation between the Oolitic flora of this part of Europe and that of the Jurassic (?) beds of India and Australia.

But these approximations which I advance here as simple conjectures require to be submitted to a profounder and more extensive

* See Mr. Bunbury's Note in the sequel.

comparative study of species. I shall be happy if the materials which are being collected in my work shall in any way contribute to this.

Note by C. J. F. Bunbury, Esq., F.G.S.

As I am at present engaged in a thorough examination of the fossil plants (supposed to be Jurassic) from India, in the collection of the Geological Society, and as I hope to lay the results of this examination before the Society in its next Session, I shall defer to a future time the discussion of several questions raised by Sign. de Zigno. I will merely observe at present, that I have great doubts whether any of the species of fossil plants found in the Indian beds are *identical with those of Yorkshire.* Certainly I have not yet seen any that are so.

Sign. de Zigno quotes me as authority for the statement that the *Glossopteris* of India has been found with a digitated frond like that of *Sagenopteris.* I must observe upon this, that this fact does not rest on my own observation. I merely mentioned in my letter that I had *heard* that the digitated form of frond had been observed in Australian (not Indian) specimens of *Glossopteris Browniana.* Among the numerous specimens of *Glossopteris,* of more than one species, both from India and from Australia, which I have now had the opportunity of examining, I have not been able to discover any indication of such a structure. The question, whether *Glossopteris* and *Sagenopteris* are sufficiently distinct as genera, is open to discussion; but, if it should be found advisable to reunite them, the name of *Glossopteris,* as the older and quite unobjectionable, ought undoubtedly to be retained.—*March* 1859.

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4. *On some* Sections *of the* Strata *near* Oxford.

By John Phillips, M.A., LL.D., F.R.S., Pres. Geol. Soc.

No. 1. *The Great Oolite in the Valley of the Cherwell.*

The value of exact records of the peculiarities of local sections is strongly felt by every geological reasoner who touches problems of the distribution of oceanic sediments, the boundaries of land and sea, the mixture or alternation of fresh and salt water, or the local origin and geographical diffusion of particular forms of life. This is specially found to be the case while considering the lines of contemporaneity in the mesozoic strata of England, in which the influences of diversified tracts of land and lines of shore, and of unequal sea-depth and varying currents, are complicated by inequalities in the duration of the several groups of organic remains.

In the district immediately surrounding Oxford, sections illustrating these causes of local diversity may have more than ordinary interest at this juncture, since here some of the Oolitic strata are supposed to die out, while below them the Upper Lias, and above

them the Cornbrash, continue unchanged in mineral character and unchanged in their organic contents; and others, as the Kimmeridge Clay and Coralline Oolite, are supposed to disappear, while either the Wealden takes a great northern development, or the Lower Greensand spreads out into an estuarine and fluviatile deposit. I propose to present, on the present occasion, sections showing the base and the top of the Great Oolite in the valley of the Cherwell. Hereafter I hope to offer similar data for the base of the cretaceous system, at Culham, in the valley of the Thames.

No. 1. Junction of Lias and Oolite, north of Oxford.

		ft.	in.
g.	Oolite, compact, marly, or shelly		
f.	Oolite, of a rough shelly character		
e.	Marly clay		
d.	Brown ferruginous sands, and sandstone with calcareous and irony layers	13	0
c.	Upper Lias Clay, enclosing a band of ironstone-nodules (*Ammonites bifrons, A. heterophyllus, Belemnites apicicurvatus*, &c.)	35	0
b.	Marlstone, solid, ferruginous	20	0
a.	Middle Lias Clay.		

This section is exemplified about Steeple Ashton, where, in 1805, it was first sketched by W. Smith*, who calls the beds by the title of "Ovenstone," a term used in the valley of the Evenlode.

At Worton, between Steeple Ashton and Banbury, the details of *d* were thus recorded in 1855:—

		ft.	in.
No. 2.	Small shells and sand, resting either on limited patches of calcareous flagstone ("plank") or on iron-ore	4	0
	Oolitic iron-ore in undulated and folded masses	0	6
	Stony bands, with plants	1	0
	Sands, with nodules of iron-ore and shells	5	6
	Calcareous band	2	0
	Water issuing from ferruginous clay (top of Lias).		

In the country about Sandford the beds marked *d* become white and yellow sand (16 or more feet thick) with irregular laminæ of calcareous sandstone, more or less blue in the centre, called "plank." This is sometimes covered by 6 feet of clay. It is the equivalent of the Stonesfield Slate, but contains only few of the fossils of this latter locality.

Ammonites heterophyllus is not known to me at any point further to the south.

The railway-cuttings and quarries near Stonesfield expose sections much resembling that given by Dr. Fitton†, especially in the circumstance that layers of clay or marly bands alternate with the white oolite. The top of the rock is uneven, worn, marked by attached *Ostreæ*, and much drilled by perforating shells. Above

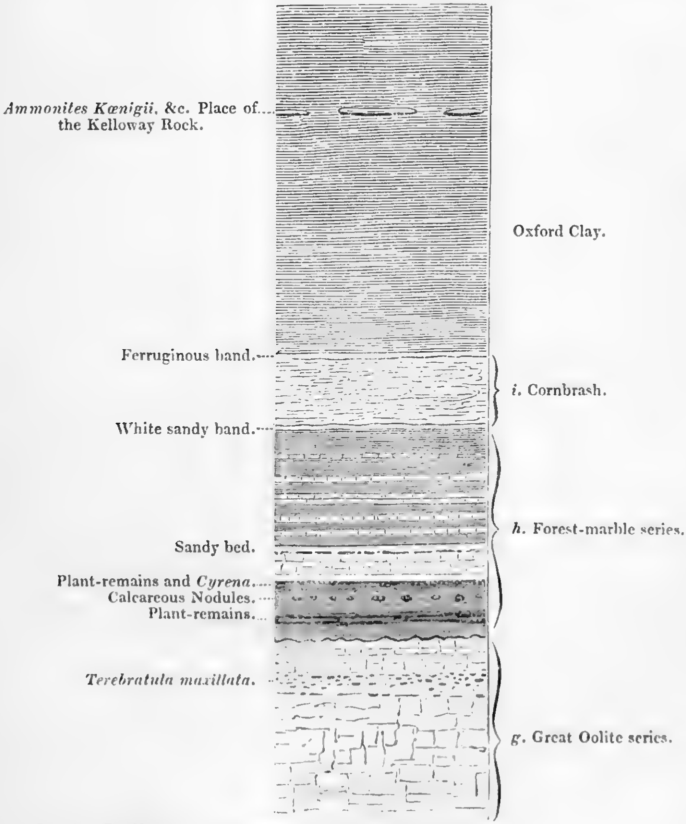
* Memoirs of W. Smith, p. 61.

† Zool. Journal, 1827.

this white oolite with *Isastræa*, *Ceromya*, *Nerinæa*, &c., and its marly partings' is usually a dark clay, 4 feet thick, with carbonized wood (jet). On this rests a variable series of shelly limestones and soft argillaceous beds, varying much and within short distances, being sometimes wholly calcareous and of the shelly character called "rag." Cornbrash lies above, with the usual fossils, *Nucleolites*, *Holectypus*, *Avicula echinata*, *Pholadomya*, &c.

The succession of the beds between the Cornbrash and Oolite is well seen at the Kirtlington Station, north of Oxford, and in the neighbouring quarries.

Section of the Strata at the Railway-station at Kirtlington, 8 miles north of Oxford.



No. 3. Railway-cutting at Kirtlington Station.

	ft.	in.
i. Cornbrash: top ferruginous; at base a white sandy nodular band (the usual fossils)	8	0
h. Forest-marble Series. Thin layers of stone and clay in many alternations varying much in thickness: viz.—		

	ft.	in.
Pale clays, and interrupted thin laminæ of shelly Forest-marble	12	0
Solid shelly bed; top oolitic, middle close-grained, base more sandy	3	9
Sandy and marly bed	0	6
Dark laminated clay, with jet (*Cyrena*)	0	10
Pale blue clay with calcareous nodules	0	8
Dark clay, with jet	0	8
Pale blue clay	0	8
Brown clay	0	9
Sandy layer	0	6
g. Oolite; the upper bed waterworn on the surface, covered by drifted *Ostreæ* and *Terebratula maxillata*		
Top bed; pale, unequal-grained	2	4
Parting.		
Bed variable in texture, usually very compact	2	6
Parting.		
Bed *full* of *Terebratula maxillata*, the valves cohering	3	0

In a quarry half a mile further west, about 40 feet more of the Oolite appears, without actually disclosing the bottom, which, however, is traceable in the vicinity, and shows sandy layers, equivalent to the Stonesfield beds.

According to the settled opinion of the Ordnance Geological Survey, the oolite of the valley of the Cherwell, with the sandy layers between it and the Lias, is entirely to be referred to the Great Oolite*. This conclusion rests on the actual tracing out of the Inferior Oolite to its extinction eastward, and to the determination of the true place of the Stonesfield beds above the Fuller's earth, in the district towards Cheltenham. This oolite, with sandy layers below, and a variable argillaceous series above (capped by Cornbrash), has been traced, by Northampton, to the cuttings in the Great Northern Railway near Stamford and Grantham†. It cannot be doubted that the series here examined continues, with no important change, through Lincolnshire to the Humber; on the north of that river the range is continued by the oolite of Brough and Cave; it is resumed, after interruption by over-extended chalk, in the oolite of Whitwell and Crambe, and recognized again in the Millepore-rock at the base of the Gristhorpe Cliffs, where it is surmounted by a variable series of shales, sands, ironstones, and several shelly bands, one specially calcareous, which are finally covered by Cornbrash.

Mr. Morris has compared these Gristhorpe beds above the Millepore-rock with the Forest-marble series of Lincolnshire; and thus it appears to be admitted that the series of Yorkshire oolites above the Lias and below the Kelloway Rock is connected with that of the Midland tracts of England by real continuity of the Great Oolite,

* See Map of the country north of Oxford. Hull in Mem. of Geol. Survey, 1857, and communication to Geol. Soc. 1859.

† Morris in Quart. Journ. Geol. Soc. 1855; see also Ibbetson and Morris, Brit. Assoc. Reports, 1847, and Brodie, Brit. Assoc. Reports, 1850.

Forest-marble, and Cornbrash. Unless, by the further progress of research into the Lincolnshire oolites, some error be found in this statement of their conformity on the one hand to the oolite north of the Humber, and on the other to the oolite of the Cherwell valley, it will be difficult to disturb the arrangement long since, though not without hesitation*, proposed, which assigns the calcareous shelly beds of Gristhorpe on the Yorkshire coast to the Great Oolite group, notwithstanding the fact that they contain some fossils which in the south of England are prevalent in the Inferior Oolite†, with many the distribution of which is not there limited to one member of the Bath Oolite series.

Possibly, in the course of this summer, it may be in my power to complete some observations in the northern parts of Lincolnshire and the southern parts of Yorkshire, and thus contribute to clear away the obscurity which still hangs over the sections of these districts. When this is carefully accomplished, we shall be able to judge whether, in the earliest classification of the Cave Oolite, in 1826, by Mr. W. Harcourt and myself‡, and in the latest notice by Mr. Norwood§ and Dr. Wright||, this rock, *on the evidence of the fossils only*, was rightly referred to the Inferior Oolite, or whether, on more general considerations, I was justified in deviating from my first opinion and giving it a higher place in the series.

May 18, 1859.

Richard Meeson, Esq., Grays, Essex; Graham Stuart, Esq., Brindcliffe, Sheffield; and Colonel Stepney Cowell Stepney, St. George's Place, Hyde Park, were elected Fellows.

The following communications were read:

1. Palichthyologic Notes.

By Sir Philip Grey Egerton, Bart., M.P., F.R.S., F.G.S., &c.

No. 12.—*Remarks on the* Nomenclature *of the* Devonian Fishes.

The "Old Red Sandstone" has recently occupied so much the attention of some of our most talented geological observers, that a kindred interest has been attracted to the examination of its fauna and flora. Of the former the Ichthyological branch is of paramount importance, inasmuch as the vast majority of the fossil remains hitherto discovered in this formation appertain to that division of the Animal Kingdom. It is therefore much to be regretted that the aid which

* Geol. Yorkshire, vol. i. edition 1, 1829, p. 150; edition 2, 1836, p. 131.

† To the list of those previously known, Dr. Wright has added *Ammonites Humphreysianus*, of which a specimen is in my own cabinet, found by me at Gristhorpe in 1855.

‡ Annals of Philosophy, 1826.

§ Brit. Assoc. Reports for 1858.

|| In communication to Geol. Soc. 1859.

might have been afforded to the general question by the accurate knowledge of the characteristic fossils, should have been so much weakened by the uncertainty which has gradually enveloped the subject, in consequence of the undue multiplication of species, the conflicting nomenclature, and rival schemes of classification propounded by those engaged in this investigation. These errors are, no doubt, to a certain extent unavoidable. The labour and difficulty of constructing from fragmentary specimens extinct forms unlike any now existing are very great. Again, when men of science in widely separated localities are engaged upon the same subject, much time must necessarily elapse before they can become mutually acquainted with each other's progress; and this knowledge, when at last obtained, is frequently defective, having to be gathered, it may be, from foreign languages, and from descriptions without figures, often meagre and unintelligible. These are certainly extenuating circumstances. At the same time a vicious practice is too prevalent—of coining genera and species with undue haste from imperfect data, and so seeking to establish what is termed the right of priority, however erroneous the determination may have been. In some of the Ichthyolitic beds of the Old Red Sandstone in Scotland, the specimens are so well preserved, that the specific characters are easily seen; in others, on the contrary, such as those of Scats Craig and Elgin, they are found in a most fragmentary and disjointed condition, consisting of detached scales, broken plates, and variously formed teeth. To determine with any degree of accuracy the characters and relations of these fragments is a task of great difficulty, and requires the utmost patience. The proportions and ornament of a scale, or the pattern of the sculptured surface of a dermal plate, are frequently the sole features we have to rely upon; and these are subject to much variation. The relative proportions of the scales to each other may vary in different parts of the same fish; those on the back and belly may be elongated or lozenge-shaped, while those on the flanks are deep or curvilinear. The surface-ornament too is by no means constant in character over the whole body. Age and sex may also cause considerable modifications. The risk is therefore great of forming new genera and species based upon data which may prove of trivial moment as our knowledge of the true characters augments. In our endeavours to steer clear of this Scylla, *variety*, we must beware of falling into the Charybdis *similarity*. The surface-patterns of the dermal plates of many of the fishes of the Devonian strata are so much alike (as, for instance, in *Asterolepis*, *Pterichthys*, and *Cephalaspis*), that fragments of each might be selected so similar in character as to lead to the supposition that they were derived from one and the same genus, and so the observer might be betrayed into the suppression of generic and specific forms through an excessive exercise of caution. Professor Agassiz has been accused of being guilty of the former fault—that of multiplying genera and species without due consideration; but in all his writings and correspondence he acknowledges this impeachment, and justifies it. In conducting a great work on the classification and description of all Fossil Fishes

submitted to his examination, it became necessary to give names to certain forms as the means of identifying the objects, and facilitating the studies of those desirous of consulting the descriptions. For instance, in many of our ichthyolitic deposits, as in the Lias and Carboniferous strata, we find various forms of teeth or palates associated with various kinds of defensive fin-bones. As no evidence was obtained as to the correlation of these forms, it became necessary to designate each by name, such names being considered provisional, until such time as the desired information should be forthcoming. The other extreme is perhaps exemplified in a recent work by Dr. Pander, on the Devonian Fishes, in which he seeks to suppress many of the Agassizian genera and species in whole or in part, and include them in one or other of the five genera constituting the family *Placodermi* of M'Coy. In this work Dr. Pander revives the discussion (which I was in hopes had been set at rest by the publication of the Appendix to Agassiz's 'Poissons du Vieux Grès Rouge') as to the priority of Eichwald's name *Asterolepis* over *Pterichthys* of Agassiz, claiming for Parrott, Quenstedt, and Kutorga the original discovery of *Pterichthys,* and for Eichwald the merit of having first named and described it. Whatever the fragments upon which these claims are grounded may be, to Hugh Miller is justly due the merit of the discovery of this singular fish. In the first edition of the 'Old Red Sandstone,' published in 1841, he thus alludes to the fact:—"Of all the organisms of the system, one of the most extraordinary is the *Pterichthys* or winged fish, an ichthyolite which the writer had the pleasure of introducing to the acquaintance of geologists nearly three years ago, but which he first laid open to the light about *seven* years earlier." This dates the *discovery* as early as 1831. The *introduction* to the scientific world was contained in a letter to Sir R. Murchison, read before the Geological Society on the 8th of May, 1839. A rival claim to the discovery of the "winged fish" has recently been put forth by the Rev. George Gordon in favour of Dr. Malcolmson and Mr. Stables, in the following passage:—"Dr. Malcolmson's noble heart reached the acme of scientific satisfaction on the 27th of March, 1839, when his friend and fellow-labourer, Mr. Stables, laid open in his presence a nodule at Lethen Bar, that *first revealed* a form clearly distinct from any previously known fossil." Dr. Malcolmson's paper was read before the Geological Society on the 5th of June 1839. It is therefore evident from the dates given above, that, although Mr. Stables may have been the first to discover *Pterichthys* in the Lethen beds, this discovery was some years subsequent to that of Hugh Miller in the Cromarty deposit. On referring to *Pterichthys* in Bronn's 'Index Palaeontologicus,' I find it thus noticed:—

Pterichthys MILL. 1840 (*i.* Brit. rept. . . . . . ; *et* Old red sandst., Edinb. 1842; *non* AG.)?=Asterolepis *Eichw.*

The cross reference is this:—

Asterolepis *Eichw.* 1840 . . . . . . ; Pterichthys MILL. (1840 *i.* Brit. rept.; Old red sandst., Edinb. 1842; *non* AG.)

The abbreviation "Brit. rept." would read, as it now stands, "British reptile;" but I do not believe this is intended, although perhaps, in reference to the first notion, that these fossils were remains of Turtles, it might tend to mislead. I rather think its signification is "Brit. Assoc. Rept." although the words are awkwardly transposed, and "Association" altogether omitted. The generic name *Pterichthys* was given to these fossils, not by Miller, but by Agassiz, on the 23rd of September 1840, as is shown at page 99 of the Report of the Meeting of the British Association at Glasgow in that year. I should not feel justified in entering at greater length into this controversy, as the rival claimants are fortunately both living, and fully able to fight their own battles; I may, however, be permitted to state that, having read both sides of the question with great care, my own impression is that Prof. Eichwald may perhaps have included in his genus *Asterolepis* some fragments which he subsequently ascertained (through the more perfect Scotch specimens sent to Russia by Dr. Hamel) to belong to the genus *Pterichthys* of Agassiz, and hence, discarding the majority, namely *Asterolepis proper*, assigns this name to the minority, to the exclusion of the Agassizian name. In the mean time Prof. Agassiz, then engaged upon his 'Poissons Fossiles du Vieux Grès Rouge,' received, through Prof. Bronn, from Eichwald himself, specimens of his *Asterolepis*, which had no reference to *Pterichthys*, but were identical with the genus *Chelonichthys*, established upon specimens brought over from Russia by Sir Roderick Murchison, and of which other specimens were found in the Orkney beds. On making this discovery, he at once relinquished his own name, *Chelonichthys*, and adopted *Asterolepis* of Eichwald. If now it is sought to supersede *Pterichthys* of Agassiz by *Asterolepis* of Eichwald, it is surely just that the term *Chelonichthys* should be retained for Eichwald's *rejectamenta*, rather than *Homosteus* of Asmus, a name of much later date than that of Agassiz. I trust, however, that this renewed attempt to overthrow the accepted nomenclature of these genera may not succeed, but that the name *Pterichthys*, sanctioned by the use of eighteen years, may be universally retained, associated as it is in the first-named species with the name of that remarkable man, the author of the 'Old Red Sandstone.'

I proceed to offer a few remarks on the additions made to the Piscine Fauna of the Devonian age, in his 'British Palæozoic Fossils,' by Prof. M'Coy. In so doing I must disclaim any desire to criticise censoriously the labours of one who has worked so assiduously in so many branches of Palæontology, and whose only fault (if fault it be) is the over-ambitious scope of his investigations. Although some years have elapsed since Prof. M'Coy first indicated, in the 'Annals of Natural History,' these additions to the Devonian Fauna, it was not until last year that I had an opportunity of examining the original specimens deposited in the Woodwardian Museum at Cambridge. The following remarks are the result of that examination combined with a previous acquaintance with all the important collections of these ichthyolites both in this country and in Scotland:—

Commencing with the family *Acanthodei*, three new species are added to the genus *Chirolepis*:—

CHIROLEPIS CURTUS.—I am unable to distinguish this species from *Chirolepis Cummingiæ*. The characters derived from the head are entirely deceptive. The obliquity of the mouth and large size of the head are owing to the dislocation of the cranial bones; and the apparent shortness of the trunk is attributable to the concealment of the nape by some of these dislocated members, and the mutilation of the extremity of the upper lobe of the tail. The scale-characters coincide with those of *Chirolepis Cummingiæ*.

CHIROLEPIS MACROCEPHALUS.—This specimen has had a squeeze, which has thrown down one ramus of the lower jaw, and forced the pectoral arch away from its normal position. If these parts are restored to their proper site, the proportional measurements differ in no respect from those of *Chirolepis Trailli*.

CHIROLEPIS VELOX.—This is a well-marked species, characterized by its small head, slender form, and large fins. The ventral and anal fins are more approximated than in *Chirolepis Trailli*.

Of the genus *Chiracanthus* three new species are described, all from the Orkney Flags:—

CHIRACANTHUS GRANDISPINUS.—This is a good addition to the genus. The specific characters are strongly marked, and it is altogether the finest species of *Chiracanthus* yet discovered.

CHIRACANTHUS LATERALIS.—I am unable to detect any specific details in which this fish differs from *Chiracanthus minor*. The preservation of the scales pierced for the mucous duct cannot be taken as a specific character.

CHIRACANTHUS PULVERULENTUS.—Tke keen eye of Prof. M'Coy has detected in the minute scales of this specimen a good and substantial specific distinction, well expressed in the term *pulverulentus*.

The last genus of the *Acanthodei*, namely *Diplacanthus*, is augmented by two new species:—

DIPLACANTHUS GIBBUS.—This species most nearly resembles *Diplacanthus crassispinus*, from which it is easily distinguished by the greater length of the dorsal spines.

DIPLACANTHUS PERARMATUS.—A very good species, differing remarkably from its nearest congener, *Diplacanthus longispinus*, in the shortness of the trunk, and the approximation of the dorsal spines.

In the family of the *Saurodipteridæ*, Prof. M'Coy proposes to substitute *Diplopterax* for *Diplopterus* of Agassiz, in consequence of the latter term having been anticipated by Boie. That this naturalist should have employed it to designate a genus of Cuckoo is hardly sufficient reason for the change; otherwise, in fairness to palæontologists, the ornithologists should be called upon to revoke *Amblypterus* and other titles to which they have no claim of priority.

DIPLOPTERUS GRACILIS.—In the absence of other structural peculiarities, I cannot accept the slender form of this specimen as a specific character. The amount of variation in this particular in the Old Red fishes is most remarkable; and, without other corroboration, mere measurement cannot be relied upon for a constant character.

Age, sex, condition, shrinkage, and compression may each and all affect individuals to a certain extent; great caution is therefore requisite in estimating the value of such variations. On examining an extensive series of any genus of Devonian fishes, transitional forms are found connecting the more slender individuals with those of grosser proportions, and thus filling up the gap which would be very perceptible if the extreme forms only were examined. This is the case in the genus under consideration; and having before me such a gradation of forms in *Diplopterus Agassizi*, I cannot but associate *Diplopterus gracilis* with that species.

Diplopterus macrolepidotus.—Prof. M'Coy seeks to substitute this name for *Diplopterus macrocephalus* of Agassiz. He states that, on examining the original specimens of *Dipterus macrolepidotus* (Sedg. & Murch.), he finds them identical with *Diplopterus macrocephalus*, subsequently described by Agassiz; he therefore associates the generic title of the latter author with the specific appellation of the former. On referring to the original memoir and figures of Sedgwick and Murchison (Geol. Journ. 2nd ser. vol. iii. p. 143, pl. 16. figs. 4, 5), I find that the specimens named "*provisionally*" *Dipterus macrolepidotus* are derived from the Caithness flags. Now *Diplopterus macrocephalus* has never been found in that locality, but is restricted to the Lethen Bar beds and some Russian deposits; consequently the alteration cannot be admitted.

Osteolepis arenatus.—This species is stated to be not uncommon in the Old Red Sandstone of Orkney. The only specimens I have met with are from the Gamrie beds, where it is of frequent occurrence.

Osteolepis brevis.—There is a small species of *Osteolepis* not uncommon in the Orkney deposits, which may well be called by this name. I have never met with a specimen so large as the one figured by Prof. M'Coy; but in other respects those I have seen appear to belong to this species. Some of the characters he assigns to it are, however, deceptive, especially the large size of the head. He remarks truly that the specimens are generally crushed vertically, but he explains this by the great width of the head; I should rather say that the great *apparent* width of the head is in consequence of the vertical crush. It was this species that afforded Hugh Miller the opportunity of making out in such minute detail the cranial anatomy of the genus; and a reference to his figures, pages 53 and 56 of the 'Footprints,' will show what the true proportions of the head are. It is the upcast of the opercular flap and the divergence of the premaxillary bones that give the "very obtusely rounded, nearly semicircular, depressed" character to the head in the figure given at pl. 2 D. fig. 4 of the Professor's work on the Palæozoic Fossils.

Triplopterus Pollexfeni.—One of the most constant characters of the *Saurodipteridæ* being the occurrence of two dorsal fins and two anal fins, the proposed genus *Triplopterus*, having only one dorsal fin, is a remarkable exception. The general shape of the body and head, as remarked by Prof. M'Coy, and the scale-characters

are so similar to *Osteolepis*, that I was at first inclined to regard it as a specimen of that genus in which one dorsal fin had not been preserved. The position, however, of the other dorsal, opposite to the anal, is a character, not of *Osteolepis*, but of *Diplopterus*, from which genus it differs in many respects, and especially in the form of the tail. I am therefore inclined to admit the validity of the genus. The figure in the 'Poissons Fossiles,' alluded to as probably belonging to this genus, is undoubtedly that of a true *Osteolepis*. In consequence of compression, the scales of the left flank are thrown up, thus exaggerating the breadth of the fish. The dorsal ridge, however, is traceable; and a large scale is visible which marks the position of a first dorsal fin in advance of, and not opposite to, the first anal fin.

In the family of the *Cœlacanthi*, the genus Glyptolepis is first noticed. In the generic character, it is described as having "*one detached ventral fin*." This must be a typographical error, as Prof. M'Coy's anatomical knowledge is too great to allow him to advance such a heterodox axiom as a one-legged vertebrate.

Immediately in succession to *Glyptolepis*, Prof. M'Coy places Dipterus, and he suggests, by a note of interrogation, that the two genera may possibly be united. I entirely agree with him in the propriety of classifying this genus with the *Cœlacanthi* rather than with the *Saurodipteridæ*; but it is very distinct generically from *Glyptolepis*. Prof. Agassiz and Prof. M'Coy are both in error in ascribing two anal fins to *Dipterus**. This has arisen from the very remote position of the ventral fins. The fringed or lobate character of these organs is peculiar to the double fins, and is never seen in the dorsal and anal fins; it therefore affords a good criterion in cases of doubt. This feature is very distinctly shown in M. Scharf's figure 3. pl. 15, Trans. Geol. Soc. 2 ser. vol. iii., and proves that this fin, which Prof. M'Coy alludes to as an anal fin, is truly a ventral fin, its fellow being concealed beneath the body of the fish. The true arrangement of the fins of *Dipterus* is admirably well shown in the wood-cut of this genus at page 287 of the last edition of 'Siluria,' where the small anterior dorsal fin is seen immediately above the lobate ventral fins. The determination of specific character in this genus is most difficult. The scales are so loosely attached that they slide over each other under the slightest pressure, concealing or exposing a greater or smaller area as the case may be; and the fin-rays are so delicate, especially in their distal extremities, and consequently so liable to abrasion or non-preservation, that little reliance can be placed on their relative length. Prof. Agassiz, after a careful examination of all the original specimens, came to the conclusion that they constituted but one species. Prof. M'Coy, on the contrary, revives the three species originally described in the memoir of Sedgwick and Murchison. The result of my own observation is, that Agassiz was justified in uniting *Dipterus brachypygopterus* with *D. macropygopterus*, but that *Dipterus Valenciennesi* ought to

* For the best description of *Dipterus*, see 'Sketchbook of Popular Geology,' by Hugh Miller, p. 246.

constitute a second species. The small size, the uniformity of depth of the greater part of the trunk, and the small expanse of the fins are characters which can be relied upon; for I have never found, in any specimen I have examined, transitional features which could indicate these as immature individuals of the larger species. This subject, however, requires further consideration.

Conchodus, new genus.—The materials on which this new generic form is constituted are so scanty, that it should be kept in abeyance until further evidence is obtained.

Holoptychius.—I entirely agree in the propriety of restricting this genus by the elimination of the larger Carboniferous species under Prof. Owen's name *Rhizodus*. It may be advisable hereafter, as our knowledge increases, to constitute this the type of a family, as it differs in many respects from the *Cœlacanthi*, and especially in having an ossified vertebral column; whereas in all the *Cœlacanthi*, from the Chalk downwards, the chorda dorsalis is persistent. The description of the generic characters of *Holoptychius* ascribes but one dorsal fin to this genus. It has undoubtedly two, the anterior one considerably smaller than the other.

Holoptychius Andersoni.—The fine specimens recently obtained from Dura Den, have satisfactorily shown that *Holoptychius Andersoni* and *H. Flemingi* can no longer be maintained as distinct species.

Holoptychius princeps.—The detached scales upon which this species is based do not differ more from those of *Holoptychius giganteus* than do those upon which Agassiz founded the two Dura Den species differ from each other. I do not think it can be upheld; certainly not without further evidence.

Holoptychius Sedgwicki.—This is a good and very distinct species. It has for many years been labelled in my cabinet as new. The anterior dorsal fin is distinctly seen in one of my specimens.

Gyroptychius.—We are much indebted to Prof. M'Coy for the definition of this new and fine genus of fossil fish, including two well-marked species, *Gyroptychius angustus* and *Gyroptychius diplopteroides*. I differ, however, with him in classifying it among the *Cœlacanthi*, with which family it has no relation. The form and structure of the fins and tail, and the mechanism of the scales, point it out as a true member of the *Saurodipteridæ*, allied to *Diplopterus* and *Osteolepis*, but differing from these genera in the surface-sculpture of the integumental covering. In comparing this genus with some other *Cœlacanthi*, Prof. M'Coy alludes to *Platygnathus* of Agassiz as being founded on the jaw of one fish and the tail of another. On referring to the description of *Platygnathus* in the 'Poissons Fossiles du Vieux Grès Rouge,' it will be seen that Prof. Agassiz had great doubts on this subject. He says, "this genus is only known to me by very incomplete fragments, of which it is difficult to say if they even belong to the same genus." He then proceeds to describe a specimen of *Platygnathus Jamesoni* as the type of the genus. The recent discoveries at Dura Den have shown that this is a good genus; they also prove that Agassiz's doubts as to the form from the Orkneys were valid. Hugh Miller considers

the latter to belong to *Asterolepis*, with the remains of which genus it is associated. *Platygnathus* is nearly allied to *Holoptychius*, but differs from that genus in the extraordinary development of the single fins.

Family Placodermata*. —This family-definition was first proposed by Prof. M'Coy, for the reception of all the genera included in the *Cephalaspidæ*, Agass., except *Cephalaspis*, together with some other genera assigned by Agassiz to the *Cœlacanthi*. Prof. Pander has adopted this family-term, and includes in it the following five genera: *Pterichthys*, Agass. (*Asterolepis*, Eichw.); *Coccosteus*, Agass.; *Asterolepis*, Agass. (*Homosteus*, Asmus); *Heterosteus*, Asmus; and *Chelyophorus*, Agass. The distinction (as I understand it) between this family and the *Cephalaspidæ* is, that whereas in the latter the head only is encased, in the former the thorax is also invested with bony plates. *Cephalaspis*, *Pteraspis*, and *Auchenaspis* would consequently constitute the *Cephalaspid* family,—*Pterichthys* and *Coccosteus* being the types of the *Placoderms*. *Chelyophorus* is probably a member of the same family. Whether *Asterolepis* and *Heterosteus* belong to it must depend upon further investigation. Hugh Miller describes the plates of *Asterolepis* as the homologues of true cranial bones, and assigns to this fish the scales figured at page 72 of the 'Footprints.' Pander, on the contrary, maintains that the small anterior plates only are true cranial plates, and that the larger plates are homologous to the thoracic plates of *Coccosteus*. The plate figured by Hugh Miller, at page 86, as a hyoid plate, Pander assumes to be the posterior dorsal plate, homologous to the large cuspidate plate of *Coccosteus*. It is clear, then, that the family affinity of this genus must depend upon the solution of this moot point. I regret I have no materials to throw light on this subject.

Pterichthys.—In the memoir on *Pterichthys* read before the Geological Society in 1848, I described two plates as the posterior ventral plates. Prof. M'Coy is quite correct in considering these as the prolongations of the posterior ventro-lateral plates. The transverse depression frequently causes a fracture in that direction, which I had erroneously considered a suture. The fin which I described as a dorsal fin is truly such, and not an anal fin, as supposed by Prof. M'Coy. I have a specimen of *Pterichthys quadratus* in profile, in which the fin is preserved *in situ*. *Pterichthys* had also two ventral fins, as conjectured by the late Lady Gordon Cumming. They are supported by spines, and are identical in form and size with the dorsal fin. I have no evidence of an anal fin.

Coccosteus. — In detailing the generic characters of *Coccosteus*, Prof. M'Coy has made a grave mistake (which led him into subsequent error) in assigning five plates as the complement of the subthoracic disc. This is the correct number in the genus *Pterichthys*; but in *Coccosteus* there are two median plates,—one central and lozenge-shaped, the other anterior and subtriangular, wedged in between the two anterior ventral plates,—making the total number six†.

* Prof. Owen objects to this term, as being synonymous with *Placoidei*.

† See Supplement.

Coccosteus microspondylus.—In the generic characters of this genus, Prof. M'Coy describes the bodies of the vertebræ as *rarely ossified*. The reservation is made in favour of this species, in which he states the bodies of the vertebræ to be *separately ossified*. If this were really the case, a structural deviation of such importance could scarcely be limited to a mere specific character. A laborious examination of all the specimens I have had access to, and of this one in particular, has satisfied me that in this genus the bodies of the vertebræ were never ossified, but that the chorda dorsalis was persistent in its embryonic condition. The form of the neurapophyses is very singular. The lower extremity of each of these swells out into a thick clavate process, simulating a vertebral body slightly abraded, in consequence of which the mistake has been made, by more observers than one, of considering them vertebral centra. Under this impression Prof. M'Coy named this species *C. microspondylus*. The bodies which he considers ossified vertebral centra are in fact the lower ends of the neurapophyses; and the "dermal bones of the dorsal fin reversed" are the hæmapophyses, the broad interval between the sets of spines being the position of the chorda dorsalis. I cannot discover that this species differs in any respect from *Coccosteus decipiens*. The latter species was originally named *Coccosteus latus* by Agassiz; but as he cancelled this specific title, and replaced it by *decipiens* in the description of the species, Prof. M'Coy would do well to adopt the latter, instead of reviving the obsolete name.

Coccosteus pusillus.—In one of the numbers of the 'Witness' newspaper, of December 1848, Hugh Miller described a "miniature Coccosteus," of which he found great numbers in a quarry near Kirkwall, to which he gave the name *Coccosteus minor* *. Prof. M'Coy published his description of *Coccosteus pusillus*, in the 'Annals of Natural History' for November 1848. Should the species be the same, of which there is little doubt, the latter name has the priority.

Coccosteus trigonaspis.—This species is founded upon the anterior median subthoracic plate of *Coccosteus decipiens*, and must consequently be cancelled.

This paper has already so far exceded the limits I originally contemplated, that I must postpone the further consideration of the subject to a future period.

SUPPLEMENT.

I have put together in the form of a supplement several extracts from letters received from the late Hugh Miller, at the time when we were both occupied with the investigation of the details of *Coccosteus*. I am not aware that these observations have been made

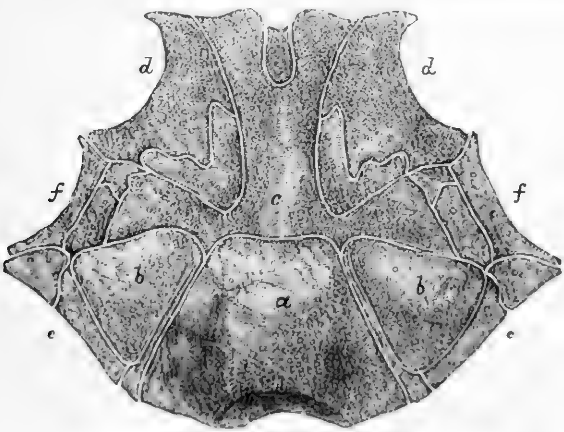
* See Supplement; and 'Cruise of the Betsey,' p. 394.

public in any of the works issued during the life of the author, nor since his decease, although it would appear, from some allusions in the course of the correspondence, that they were communicated either in the form of lectures or in the columns of the 'Witness.' The anatomical minutiæ are so clearly and accurately described, that it is due to the fame of their talented author, as well as advantageous to palæontological knowledge, that they should be communicated to the public.

Letter dated March 25, 1848.

"The gutta-percha impression you sent me must be that of a portion of the under part of the head of a small *Coccosteus*. I am acquainted with the peculiarly marked lozenge-shaped plate, and possess two specimens of it; but both present their inner surfaces. In the one specimen, an Orkney one, it is altogether detached, occurring solitary on the stone; in the other, from Cromarty, it is associated with plates of *Coccosteus*, resting, though not in its proper place, almost in contact with the plate which described the under part of the orbit of the creature's eye,—a plate, by the way, not given in Agassiz's restoration, though exhibited in some of his renderings of specimens. The eyes of the *Coccosteus* were placed, not

Fig. 1.—*Portion of the Under Part of the Head of a small* Coccosteus.



under the transverse portions of the cruciform plate *c*, fig. 1, but, as demonstrated by at least two of my specimens, under the angular plates *d*, and, instead of being surrounded by a ring of small plates, were nearly, if not altogether, encircled by curves scooped out of two larger ones—plate *d*, and the paddle-shaped plate which you may find resting on the former in the single figure of tab. 8*, on the left hand side, and on the right hand side of fig. 4 of tab. 9.

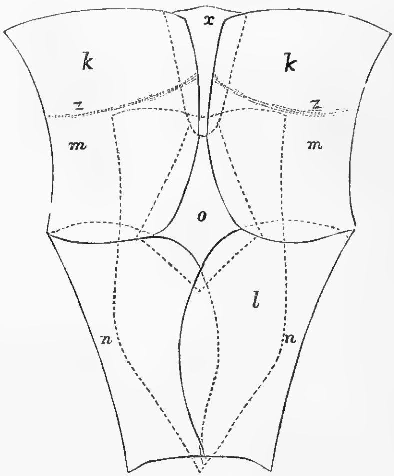
* Poissons Fossiles du Vieux Grès Rouge.

"There occurs in Orkney, in the neighbourhood of Kirkwall, and in Caithness, in the neighbourhood of Thurso, a small *Coccosteus* which, if not the young of *Coccosteus oblongus*, must be an undescribed species."

Letter dated April 3, 1848.

"Your gutta-percha impression has sent me to my specimens; and I have at length succeeded in determining the true place of the angular plate. In Agassiz's restoration of *Coccosteus*, tab. 6. fig. 4*, there are five ventral plates, indicated by dotted lines,—four of them lateral ventral, marked *m m*, *n n*, and a central lozenge-shaped plate marked *o*. The anterior lateral ventral plates, *m m*, are, however, nearly four times as large in both *Coccosteus oblongus* and *Coccosteus cuspidatus* as in the restoration (those of *Coccosteus decipiens* I have not seen); and, instead of terminating at their upper extremity at the top of the lozenze-shaped plate *o*, they run on to the top of the omitted angular plate, the point of which rests in a hollow scooped out of the top of the lozenge-shaped one. The measurements of the plates in the following rude sketch (fig. 2), are

Fig. 2.—*Outline of the Plates of* Coccosteus.



taken from those of an actual specimen. Your specimen exhibits the plates *x* and *o*, and one of the plates *m*; and the species to which it belonged is, so far as I can determine the point, *Coccosteus oblongus*. The individual was small, smaller even than the one whose ventral plates I have indicated in my draught, though considerably larger than the Orkney and Thurso species to which I referred in my communication of the 25th ult. The letter *z* marks a pseudo-joint, which, judging from your gutta-percha cast, is well marked in your specimen. Between the lateral ventral

* Poissons Fossiles du Vieux Grès Rouge.

plate, *m*, and the arched dorsal plate, *l*, there occurred two lateral plates of considerable size, omitted by Agassiz, and which corresponded to the two dorsal lateral plates of *Pterichthys*. It is a curious circumstance, that both genera had the same number of plates, eleven, in the cuirass which covered the body,—the *Pterichthys* having two central dorsal plates, and but one central abdominal plate, and the *Coccosteus* but a single dorsal plate, and two central abdominal ones. In both, too, the body impinged further on the head ventrally than dorsally. The anterior end of the dorsal plate of *Coccosteus* terminated nearly opposite the line *z*."

Letter without date.

"In the concluding part of my very rambling geological chapter of to-day, you will find reference made to what I deem a new species of *Coccosteus*, and in the enclosed little box the cast of one of the best specimens of the species, or variety, yet found (fig. 3).

Fig. 3.—*Plates of* Coccosteus pusillus, *M'Coy.*

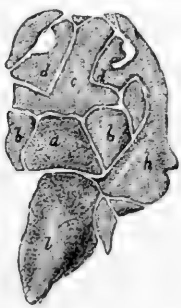
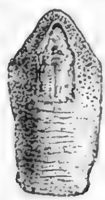


Fig. 4.—*Dorsal Plate of* Coccosteus pusillus, *M'Coy.*



It shows, on at least two of the plates, the numerous tubercles, varying from microscopic to minute, on which I have ventured to challenge for it a specific status, and also the eye-hollows referred to in my description, but not those lines of increment which I also found. These, however, are very apparent on the cast of the single dorsal plate (fig. 4) which accompanies it, and which, for this species, is large. By letting the light fall slantwise on this latter cast, you will see the plate reduced by line within line till, at length, in the centre it appears as a miniature thing, little more than half an inch in length by about the eighth part of an inch in breadth. In the cast of the more perfect specimen, there is a slight distortion indicated in this dorsal plate; but it seems to be merely the result of some accident peculiar to the individual, and is not shown in any of the other specimens. I purpose in my next chapter attempting a general description of *Coccosteus*, which, however, from the want of a print, cannot, I am afraid, be other than obscure."

Letter dated October 6, 1848.

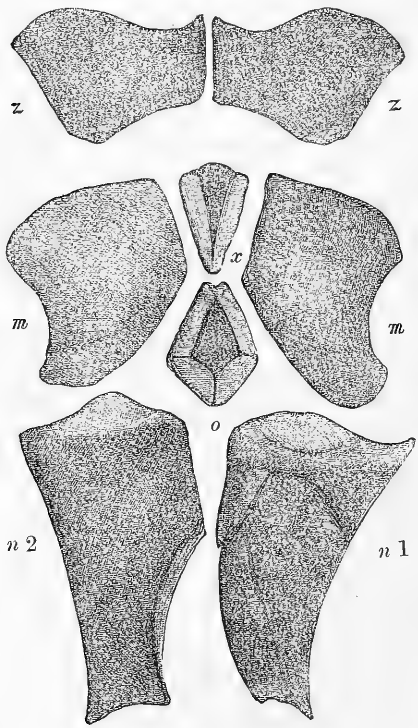
"Since I had the honour of corresponding with you in spring last, I have seen plates of the ventral surface of *Coccosteus*, which fully corroborate the sketch in outline I attempted in one of my communications."

Letter dated December 9, 1848.

"Your favour of the 4th reached me three days ago; but I delayed reply till now, that I might be able to send you my promised description of the *Coccosteus* and the accompanying casts. These last pretty fairly represent the prints with which, when I collect my chapters into a volume, I shall attempt illustrating the chapter of to-day; and should the engravers succeed in doing the subject as much justice as my bits of plaster do it, I shall be well content.

"One of the number (fig. 5) is a composition of abdominal plates

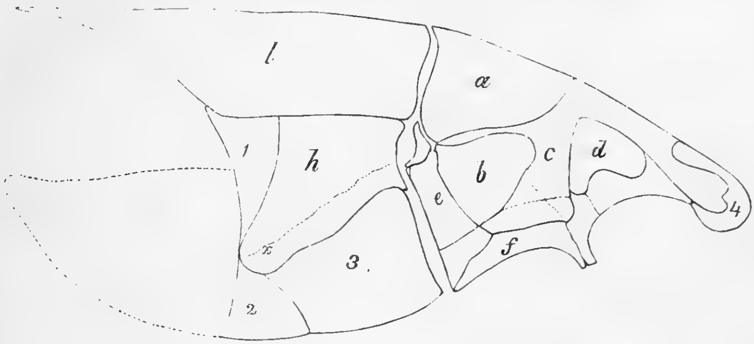
Fig. 5.—*Abdominal Plates of* Coccosteus Milleri.



ranged in what, I think, you will find to be the original order; the others are transcripts of four of my finer and more instructive specimens.

"Fig. 6 is that of the specimen which I have described as unique. You will see, on examining the plaster, that the upper profile line

Fig. 6.—*Lateral View of the Cuirass of* Coccosteus Milleri.



marked in dark grey is not quite that of the fossil, which exhibits (like what portrait-painters term a two-thirds front face) part of the other side,—at least, nearly the whole of plates *l* and *a*, and the whole central part of plate *c*, with the little oval plate which the latter includes. But by running my colour edge direct through the centre of these plates, I have gained, I think, the true line of profile, and, what is of importance in restoring the *Coccosteus*, have ascertained nearly the angle which the frontal line of the head formed with that of the back. The slip of shaded paper (fig. 7) which accompanies the cast completes the restoration; and the *tout ensemble* forms, instead of the monster I once deemed *Coccosteus*, a not inelegant little fish.

"Fig. 8, a cast of the lateral plate *h* of the cuirass, exhibits the pin or tenon which fastened the armour of the head to that of the body. The two pins, bent towards each other, I have described as forming, between them, a dovetail-joining. How simple, and yet how beautiful, the contrivance! The squamose sutures on the exterior of this plate were very broad. It was overlain by the dorsal plate *l*, and by the lateral plate 3, but in turn overlay the angular plate 1, immediately beneath it. My cast indicates this nether suture at the mark *x*; the seeming sutures at either end are mere fractures. Externally the plate bore a pseudo-suture, which (in fig. 6) I have also marked *x*.

"In the restoration, fig. 5, the plates *n* 1, *m m*, and *x*, are furnished by one individual, and bear, of course, the true proportions each to the others; the plate *n* 2 is from another and slightly larger individual; while the central plate, *o*, as I had none of my own that were not greatly too large, I have borrowed from the gutta-percha squeeze which you kindly sent me last spring. It is, however, rather small for fitting rightly into the other plates.

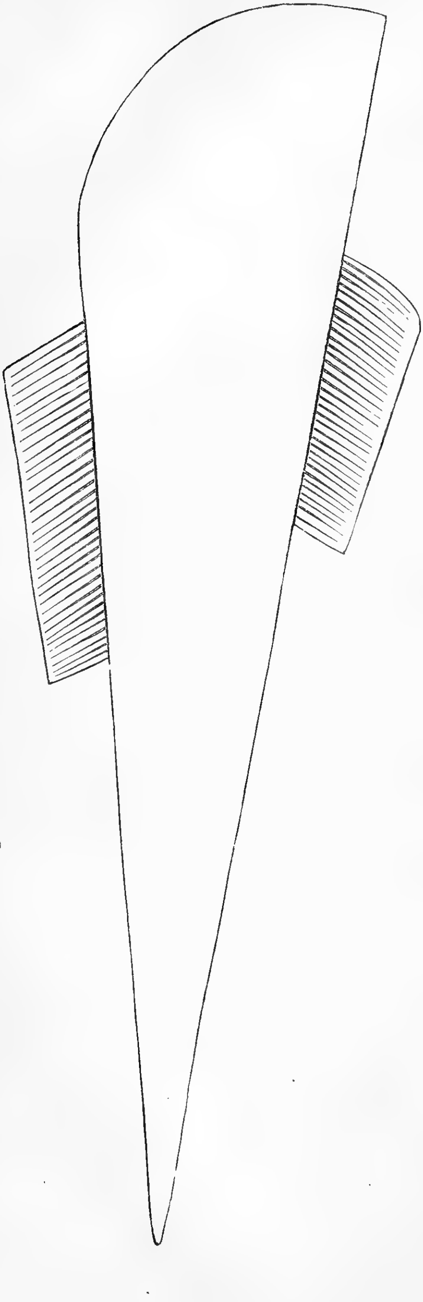


Fig. 7.—*Outline of the Tail of* Coccosteus.

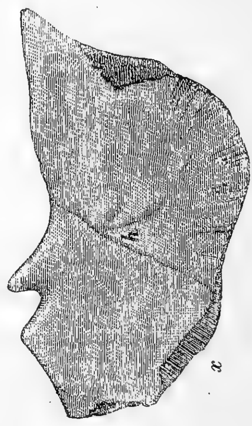


Fig. 8.—*Inside view of one of the lateral Plates of* Coccosteus.

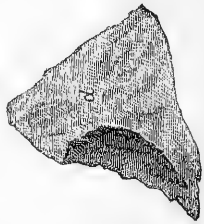


Fig. 9.—*Inside of one of the cephalic Plates of* Coccosteus, *showing the hollow of the Orbit.*

"The small cast, fig. 9, shows the deep hollow of the eye-orbit of *Coccosteus*, as scooped out of the under side of plate *d*, fig. 6. The specimen from which it is taken shows the whole inferior surface of the occipital buckler and the hollows of both eyes.

"The cast, fig. 3, that of a head in a beautiful state of keeping, seems to illustrate the profile of the head seen in the cast, fig. 6.

"I would fain have sent you a few illustrative casts more,—among others, a cast of the paddle-shaped plates which lay under the eyes, and described the nether half of the orbit; but my little box refuses to accommodate more. These plates, however, you will find figured by Agassiz in his 'Old Red,' tab. 8, and in tab. 9. fig. 1. The narrow neck-like stem, which I have compared to the claw of an anchor, swept round the eye-orbit; and the rounded sweep of the paddle-blade or anchor-fluke fitted into the hollow on the outer edge of plate *f*, which is so well marked in my casts, figs. 1 & 6."

Letter dated December 23, 1848.

"I cannot regard the species of *Coccosteus* to which the plates of my cast in last parcel (fig. 5), or that of the unique specimen fig. 6, belong, as *Coccosteus decipiens*. Both its dorsal plate, *l*, and its occipital plate, *a*, are longer in proportion to their breadth than those of that species. Agassiz, however (in tab. 10. fig. 1), has figured an individual of this species, from my collection, as *Coccosteus decipiens*. Its proportions are rather those of *Coccosteus cuspidatus*, though its dimensions are smaller. The very fine head from which the cast No. 1 was taken belonged to an individual of larger size and greater proportional breadth."

Note.—I quite agree in the propriety of considering this a distinct species. In addition to the characters alluded to above are the following:—The central abdominal plate has the posterior angle more obtuse than the anterior one; and the angular or dagger-shaped bone in advance of it is considerably narrower than in any other species. The tubercles are very numerous and uniform in size. I propose to signalize the species as *Coccosteus Milleri*.—P. E.

Letter dated February 3, 1849.

"I send you a cast of a tolerably good specimen of two of the lateral plates of *Coccosteus*—those overlain on their upper edge by the dorsal buckler. They have been sufficiently displaced in the original to show the squamose sutures, which were not shown in the cast of my unique specimen. The pin which attached the cuirass to the head belonged, as shown by one of my former casts, to the interior surface of plate *h*: its outer surface exhibits a minute groove instead."

I have a subsequent letter, dated January 26, 1850, describing the structure of the jaws of *Coccosteus*; but as this subject was communicated in a paper to the Physical Society of Edinburgh, and is

also described at p. 208 of 'The Sketch-book of Popular Geology,' it is needless to introduce it here. Feeling confident that no apology is due for submitting to the Geological Society the foregoing passages from the pen of one of the most original and philosophical writers of the age, I will close the series with a paragraph highly characteristic of the resolute yet patient method of his scientific labours:—

"For my own part, I am determined to go stubbornly on, adding fact to fact, and testing earlier by later observations, convinced that, if I succeed in getting Truth out of the deep well in which, in this game of Ichthyolitic reading, as in so many others, it is her nature to hide herself, her identity will be ultimately recognized, however authoritatively it may be challenged or denied on her first appearance."

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2. *On the* Yellow Sandstone *of* Dura Den *and its* Fossil Fishes. By the Rev. John Anderson, D.D., F.G.S., &c.

[This Paper was withdrawn by the Author with the permission of the Council.]

(Abstract.)

In his geological remarks on Dura Den, the author described the sedimentary strata in the vicinity as consisting of (in ascending order)—1. Grey sandstone, the equivalent of the Carmylie and Forfarshire flagstones, with *Cephalaspis* and *Pterygotus*. 2. The red and mottled beds, such as those of the Carse of Gowrie, and the Clashbennie zone with *Holoptychius nobilissimus*, *Phyllolepis concentricus*, and *Glyptolepis elegans*. 3. Conglomerates, marls, and cornstone, with few and obscure fossils. 4. The Yellow Sandstone, rich in remains of *Holoptychius* and other fishes, and about 300 or 400 feet in thickness. This sandstone is seen to rest unconformably on the Clashbennie series of the Old Red at the northern opening of the Den, and at the southern end is unconformably overlain by the Carboniferous rocks. It is also exposed beneath the lower coal-series of Cults, the Lomonds, Binnarty, and the Cleish Hills. It is seen also in Western Scotland (Renfrewshire and Ayrshire), and in Berwickshire and elsewhere in the south, with its Pterichthyan and Holoptychian fossils. In the author's opinion it is entirely distinct from the "Yellow Sandstone" of the Irish geologists.

At Dura Den one thin bed in the Yellow Sandstone especially teems with fossil fish. The Pamphractus-bed, towards the top of this thick deposit, is the only other stratum bearing fossil remains.

In 1858 a remarkably fine *Holoptychius Andersoni* was met with in the fish-bed; and this, with many other specimens, fully bears out Agassiz's conjectures for completing the form and details of the fish where his materials had been insufficient. Dr. Anderson thinks that the supine position of the *Holoptychii* is of rare occurrence; he has observed them usually to lie on their side. *H. Andersoni* and *H. Flemingii* are regarded by the author as specifically one, as he

has not been able, in the numerous *Holoptychii* that he has seen, to regard as distinct the differences pointed out in the descriptions of these two reputed species.

Dr. Anderson also offered some remarks on the *Glyptopomus minor* (Agass.), the specimen of which was obtained from this locality; and he drew attention to two as yet undescribed fishes*, also from Dura Den.

June 1, 1859.

James Lamont, Esq., Knockdow, Argyllshire, and William Longman, Esq., 36 Hyde Park Square, were elected Fellows.

The following communications were read:—

1. *On the* Sinking *at* Shireoak Colliery, Worksop, *to the* "Top Hard Coal" *or* "Barnsley Coal." By John Lancaster, Esq., and Charles C. Wright, Esq., F.G.S.

As the sinking at Shireoak to the "Top Hard or Barnsley Coal" is not only in a new district, but has also been carried through a considerable thickness of Permian rocks and Coal-measures which have not been proved elsewhere, we venture to think that our sections and some account of the strata passed through will be of interest to this Society.

In March 1854 Mr. Lancaster commenced sinking two pits for the Duke of Newcastle on the north-western side of his Worksop Manor Estate, where the Coal-measures are overlaid by a considerable thickness of Permian rocks. A bore-hole had been sunk some years previously on the same estate by Mr. John Woodhouse, to prove the minerals; and, though it was carried to a depth of more than 300 yards, no satisfactory results were obtained, no workable coal or ironstone being found.

* These specimens having been submitted to Prof. Huxley for description, have been respectively named by him *Phaneropleuron Andersoni* and *Glyptolæmus Kinnairdii*. See 'Dura Den; a Monograph of the Yellow Sandstone,' &c., by J. Anderson, D.D., F.G.S. 1859.

[*Table*

Table of the Strata passed through in sinking to the "Top Hard Coal" by His Grace the Duke of Newcastle, at Shireoak, Nottinghamshire.

Description of Strata.	Thickness.			Depth.		
	yds.	ft.	in.	yds.	ft.	in.
Permian marls and sandstones	18	2	6	18	2	6
Yellow limestone	18	2	8	37	2	2
Grey limestone	15	1	0	53	0	2
Blue shale and rock	6	2	3	59	2	5
Blue shale	11	0	9	71	0	2
Sand-rock	0	1	8	71	1	10
Warren earth	1	0	0	72	1	10
Blue and red bands with ironstone ..	1	2	11	74	1	9
Ironstone	0	1	4	75	0	1
Black shale	0	0	2	75	0	3
Shale and rock	10	0	0	85	0	3
The Manor coal	0	2	0	85	2	3
Blue shale	5	0	0	90	2	3
Grey and red rock	66	0	0	156	2	3
Coal	0	1	4	157	0	7
Rock and shale	13	0	8	170	1	3
Black shale	0	2	6	171	0	9
Fire-clay	2	0	2	173	0	11
Coal and black shale	0	1	4	173	2	3
Shale	3	2	10	177	2	1
Coal	0	1	4	178	0	5
Fire-clay	2	1	3	180	1	8
Shaly coal and ironstone, 4 inches ..	0	1	6	181	0	2
Shale	5	2	3	186	2	5
Coal	0	0	9	187	0	2
Fire-clay	0	2	7	187	2	9
Shale and coal	0	1	0	188	0	9
Rock	2	2	4	191	0	1
Coal	0	0	8	191	0	9
Blue shale	6	0	0	197	0	9
Shaly coal	0	0	3	197	1	0
Rock and metal	8	2	4	206	0	4
Coal and black shale	0	1	11	206	2	3
Shale	1	2	9	208	2	0
Rock-bands	10	2	3	219	1	3
Black shale and ironstone, 5 inches .	4	0	4	223	1	7
Fire-clay and shale	2	2	0	226	0	7
Coal	0	1	2	226	1	9
Shale and rock	5	1	0	231	2	9
Coal	0	0	4	232	0	1
Shale and rock	3	0	4	235	0	5
Coal and shale	0	0	6	235	0	11
Shale	3	0	5	238	1	4
Bands of rock	10	2	4	249	0	8
Shale and ironstone-bands	10	2	6	260	0	2
Shale	8	1	2	268	1	4
Coal	0	0	8	268	2	0
Rock and shale	8	0	7	276	2	7
Coal	0	1	0	277	0	7

Table of Strata continued.

Description of Strata.	Thickness.			Depth.		
	yds.	ft.	in.	yds.	ft.	in.
Rock and shale	23	1	10	300	2	5
Coal	0	0	7	301	0	0
Shale and ironstone	16	2	0	317	2	0
Inferior coal	0	1	2	318	0	2
Shale	7	1	6	324	1	8
Coal	0	0	5	324	2	1
Rock and shale	15	0	0	339	2	1
SHIREOAK, MELTON, CLOWN, or WATHWOOD COAL	1	1	4	340	0	5
Shale	18	1	0	358	1	6
Inferior coal	1	0	2	359	1	8
Warren earth	1	1	6	361	0	2
Strong rock	4	0	5	365	0	7
Measures (with thin beds of *coal*)	15	0	5	380	1	0
FURNACE-COAL	0	2	8	381	0	8
Measures	8	0	1	389	0	9
Coal	0	1	6	389	2	3
Fire-clay	0	1	4	390	0	7
Coal	0	1	0	390	1	7
Shale and rock	13	2	8	404	0	3
Coal	0	2	1	404	2	4
Shale and rock	3	2	9	408	2	1
Coal	0	0	6	408	2	7
Shale and rock	18	2	3	427	1	10
HAZLES COAL	1	0	1	428	1	11
Dirt in coal	0	0	7	428	2	6
Rock and shale	10	2	2	439	1	8
Shell-bed	0	0	2	439	1	10
Shale	19	2	3	459	1	1
Coal	0	1	4	459	2	5
Shale and rock	42	2	1	502	1	6
Coal	0	0	7	502	2	1
Shale	5	0	7	507	2	8
HARD COAL	1	0	9	509	0	5
Dark warren earth	0	0	3	509	0	8
Blue shale	2	1	6	511	2	2
Proved by Boring.						
Rock and shale	14	1	4	526	0	6
Coal and shale	0	0	7	526	1	1
Blue shale and ironstone-bands	11	0	0	537	1	1
Ironstone	0	0	7	537	1	8
Rock and shale	8	1	5	546	0	1
Black shale	0	2	5	546	2	6
Warren earth	0	1	2	547	0	8

The Permian beds are, we think, better developed here than at any colliery where they have been sunk through, though their total thickness is only 207 feet. The upper beds, as will be seen from the vertical section (p. 143), consist of thin and alternate layers of

soft sandstones and red marls, which attain a total thickness of 60 feet. The Magnesian Limestone, however, forms the thicker portion. We found it divided into two principal beds; the Yellow, which was very hard and crystalline, 54 feet thick; and the Blue below it, containing bands of blue shale, 20 feet thick. Both together yielded 66 gallons of water a minute in our pits.

Below the limestone we met with 33 feet of blue shale, which made but little water; and we then reached a very soft gritstone, 5 feet thick, which we consider the lowest bed of the Permian in our pits. It is of the same character as a rock met with in a similar position at Patricroft near Manchester; and we have no doubt that it is the equivalent of the "Quicksand," so well known in the Durham district.

Below the gritstone the Coal-measures begin with 5 feet of blue shale, in which there are four bands of ironstone, and, immediately below, a bed of the same stone, 15 inches thick, but of a richer and apparently more regular character.

The ore is principally in the state of peroxide, and the bed and bands give an average of 42 *per cent.* of metallic iron, according to the result of four analyses made in Dr. Percy's laboratory. The following analysis, made by Mr. William Baker, shows the exact composition and distribution of the constituents of the main bed:—

100 parts, dried at 212° Fahr., gave

Peroxide of iron	63·110
Lime	5·174
Alumina	4·170
Silica	6·545
Sulphuric acid	0·293
Phosphoric acid	0·083
Carbonic acid	9·702
Water (in combination)	10·936
	100·013

The above peroxide corresponds to 44·17 *per cent.* of metallic iron. The distribution of the constituents of the ore may be stated thus:—

Hydrated peroxide of iron $2(Fe^2O^3+3HO)$	61·435
Carbonate of protoxide of iron	15·293
Carbonate of lime	8·869
Sulphate of lime	0·629
Hydrated silicate of alumina	12·650
Phosphoric acid	0·083

The lime present, being scattered through the stone in small oolitic grains, gives the ore a very mottled appearance. As might be expected, it is not affected by exposure to the atmosphere, though very easily pulverized. At present it has only been proved in our pits, which are 50 yards apart; but Messrs. Dawes are now sinking a pit, and will determine its regularity. It resembles the Froghall ore of North Staffordshire, and a bed found at Patricroft in a similar position as regards the limestone, more closely than any other ironstone of the Coal-measures.

The first seam of coal was cut November 1855, at a depth of 88 yards; this is 2 feet thick, and of inferior quality.

Four yards below this we met with a compact sandstone or grit, which proved to be 66 yards thick, and of a very hard and open character. On the rise towards the west a great portion of it is covered by the Magnesian Limestone; but it crops out at Harthill, four miles west of Shireoak, and is there extensively worked for scythe-stones, &c.

We were one year and eight months in sinking through this rock, and the total quantity of water made in each pit was 500 *gallons a minute*: this was, however, stopped in detail by cast-iron tubing, which was carried down to a depth of 170 yards from the surface. When it was first put in, we experienced some difficulty from the gas given off at the bottom of the thick rock, which, when pent up, injured some of the tubing. Pipes were, however, put in to carry the water to the surface; since then the pressure, as proved by a gauge, has been more regular. It has been as high as 210 *lbs. per square-inch*; but is now about 196 lbs. per square-inch.

Below this point no difficulties were encountered, the strata consisting principally of shales which were free of water.

Several coals and bands of ironstone were met with in the next 170 yards; but they were all thin or of inferior quality.

At 346 yards we cut the first thick coal, and found it to be 4 ft. 6 in. thick and of good quality. Practical geologists and engineers in the neighbourhood considered this to be the "Wathwood coal" of the Derbyshire and South Yorkshire district, where it averages about 4 feet thick; and we found it to be at nearly the same distance from the "Hard Coal" that it has been proved in those fields.

The principal coals between the "Wathwood" and the "Top Hard Coal" were found of very much the same quality, and with the same thickness of intervening strata, as known elsewhere.

On February 1, 1859, the "Top Hard Coal" was cut at a depth of 510 yards, and found to be 3 feet 10 inches thick. It gave the accompanying section in our pits, from which it will be seen that the "Bright" portion, which is of considerable thickness elsewhere, is nearly absent here.

10 inches.	Soft.
10 inches.	Hard.
3 inches.	Bright.
12 inches.	Spiry, or mixed hard and soft.
11 inches.	Soft.

The nearest workings to ours in this coal are at the Comberwood Colliery near Killamarsh; and, though these are $5\frac{1}{2}$ miles from Shire-

oak, so little gas is given off from the coal that we experience no difficulty at present in working with naked lights.

The following are the points of greatest interest proved by this sinking:—

1. The existence of a soft sand-rock at the bottom of the Permian beds in this district, which seems to be the equivalent of the "Quicksand" of the north.

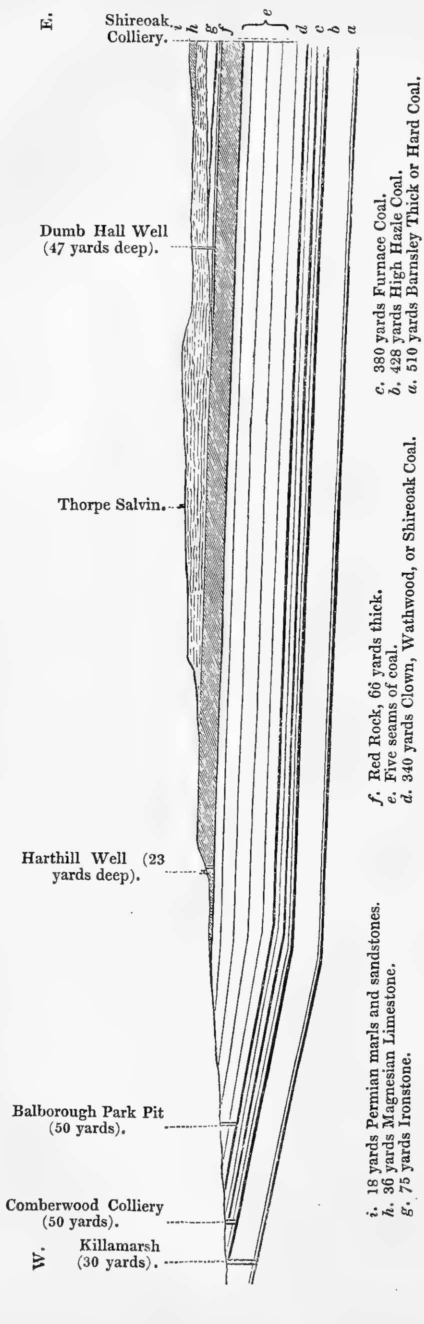
2. The absence of any workable seam of coal in this district, at least in the 300 yards of coal-measures above the "Wathwood" or "Shireoak Thick Coal." Thirty-seven feet of coal were passed through in the sinking, but only four seams are of a workable thickness.

3. The existence of a Red Ironstone in the upper measures, which promises to be of great commercial value.

4. The "Top Hard Coal" seems to thin out towards the east under the Magnesian Limestone; for at Killamarsh and near its outcrop, six miles west of Shireoak, it is 6 feet thick, while with us it is only 3 feet 9 inches.

The "Wathwood coal" being found within one yard of the

Cross-section from the Shireoak Colliery to the Outcrop of the "Hard Coal" near Killamarsh.—Distance 5 miles.



depth calculated from the dip of the strata, would lead to the supposition that the new district is remarkably free from faults; and this supposition is further borne out by the large bodies of water met with—so large, indeed, that the greatest credit is due to the Duke of Newcastle for the perseverance he has shown in carrying on the undertaking single-handed.

We find the dip decreases considerably towards the east, the strata coming more into a basin-form. At the Comberwood Colliery the dip varies from 1 in 6 to 1 in 12; while at Shireoaks it undulates considerably, but we have never observed it more than 1 in 36 (see fig., p. 142).

Details of the Section at Shireoak Colliery.

	yds.	ft.	in.
Pit-bank	5	2	3
1. Soil	0	2	8
2. Sand	1	1	0
3. Rocky red sandstone	1	1	0
4. Light and red rock	1	0	0
5. Red marl	1	0	0
6. Red rock	2	0	0
7. Red marl	2	1	1
7. Red marl	1	0	10
8. Light sandstone	0	1	6
9. Red marl	1	0	6
10. Red sandstone	1	0	5
11. Red marl	1	0	10
12. Light sandstone	0	2	9
13. Red marl	0	1	2
14. Light sandstone	1	0	6
15. Magnesian limestone	13	1	3
16. Light-blue close stone	1	2	0
17. Dark-blue limestone	14	1	8
18. Limestone-bands (6 to 12 inches), with bands of blue metal	6	1	0
19. Blue bind	11	0	0
20. Grey sand-rock	2	1	6
21. Black shale	0	0	1
22. Blue warrant mixed with red	0	1	8
23. Blue and light-red bind, with ironstone	1	1	8
24. Black shale	0	0	7
25. Ironstone	0	1	1
26. Blue and red warrant	0	0	3
27. Shaly coal	0	0	2
28. Blue bind	0	2	0
29. Blue bind	1	0	0
30. Grey sand-rock	2	0	5
31. Blue bind, with thin bed of ironstone	6	2	7
32. Coal	0	2	0
33. Blue warrant	0	2	2
34. Strong blue bind	4	0	5
35. Rotherham thick rock	66	1	5

The following features were here observed in the Rotherham thick rock:—

Yds. from its top.
At $3\frac{1}{2}$, 18,000 gal. of water pr. hour.
At $9\frac{1}{2}$, 1250 gal. of water per hour.
At $13\frac{1}{2}$, 1400 gal. of water per hour.
At 16, red marl, 6 inches thick.
At 17, marl and grey rock.
At 22, bed of red marl, 1 ft. 4 in. thick.
At 25, 5000 gal. of water per hour.
At 29, hard bed of rock, 3 yds. thick.
At 43, 2 yds. of very hard rock.
At 53, 6400 gal. of water per hour.
At 63, 5 yds. of very hard rock.

	yds.	ft.	in.
36. Coal	0	1	4
37. Blue shale	4	1	2
38. Grey rock (bed of dark metal in middle; 1 ft. 6 in., 450 galls. of water per hour)	7	0	3
39. Blue shale	1	2	2
40. Black shale (with black-band ironstone, 6 in.)	0	2	5
41. Fire-clay	2	0	2
42. Coal and shale	0	1	4
43. Fire-clay	0	1	8
44. Blue metal	2	2	8
45. Black shale	0	1	2
46. Blue shale (ironstone, 4 in.)	1	0	7
47. Coal	0	0	8
48. Fire-clay	0	2	10
49. Coal and shale	0	0	4
50. Fire-clay	1	1	1
51. Coal	0	0	5
52. Black metal (with ironstone, 3 inches)	0	1	1
53. Blue shale	4	2	9
54. Black shale	0	2	6
55. Coal	0	0	9
56. Fire-clay	0	2	7
57. Shaly coal	0	0	5
58. Black shale	0	0	7
59. Rock	0	2	3

	yds.	ft.	in.
60. Blue metal mixed with rock	2	0	1
61. Coal (good)	0	0	8
62. Blue metal	1	1	0
63. Rock	0	0	6
64. Blue metal	4	1	5
65. Shaly coal	0	0	3
66. Rock	2	0	1
67. Strong blue shale	6	2	3
68. Coal (inferior)	0	0	11
69. Black shale	0	1	0
70. Stony fire-clay	1	0	8
71. Blue shale	0	2	1
72. Thin rock-bands	0	2	0
73. Grey layers	0	2	3
74. Rock-bands	2	0	1
75. Rock and grey layers	2	0	6
76. Rock	1	1	0
77. Grey layers	3	2	5
78. Blue shale	2	2	1½
79. Black shale, with ironstone, 5 inches	1	1	3
80. Fire-clay	1	1	0
81. Light soft blue metal	1	1	0
82. Coal (good)	0	1	2½
83. Stony fire-clay	1	1	0
84. Strong grey layers	1	0	0
85. Light-blue metal	2	0	1
86. Dark-blue metal	0	2	11
87. Coal	0	0	4
88. Dark fire-clay	1	0	8
89. Soft blue metal	0	2	0
90. Grey stone-band	0	0	6
91. Blue metal	1	0	2
92. Coal and shale	0	0	6
93. Dark fire-clay	1	0	5
94. Light-blue metal	1	0	0
94. Dark-blue metal	0	2	2
95. Black shale	0	0	10
96. Rock	0	1	0
97. Blue metal	0	0	4
98. Light rock	0	0	8
99. Dark-grey metal	1	0	9
100. Light rock	0	0	10
101. Dark-grey metal	1	1	0
102. Light rock	2	1	0
103. Dark-grey metal	1	0	0
104. Light rock	0	2	3
105. Dark-grey rock	2	0	2
106. Dark-grey layers	1	0	4
107. Blue metal	7	0	2
108. Black shale	1	0	0
109. Soft blue metal, with ironstone	2	2	6
110. Dark-blue metal	4	0	4
111. Hard black stone	0	1	6
112. Light fire-clay	1	2	0
113. Light-blue metal	2	2	4
114. Dark shale	0	1	0
115. Coal	0	0	8
116. Light fire-clay	0	2	0
117. Rock and metal	1	1	0
118. Blue metal	3	0	4
119. Dark-blue metal	3	0	3
120. Coal	0	1	0
121. Fire-clay	0	2	0
122. Blue metal	2	0	3
123. Fire-clay and coal, 4 in.	1	2	1
124. Light-blue shale	1	2	1
125. Grey metal	1	0	0
126. Strong grey layers with rock-bands	4	0	0
127. Strong rock	12	1	5
128. Coal	0	0	7
129. Light fire-clay	1	0	2
130. Dark warrant	0	2	0
131. Blue metal (with ironstone, 7 inches)	1	2	2
132. Dark shale	7	2	7
133. Black shale	2	0	2
134. Blue shale	2	1	0
135. Black shale	1	0	0
136. Inferior coal	0	1	2
137. Stony warrant	1	1	2
138. Grey layers	0	2	5
139. Blue shale	2	0	1
140. Dark shale	1	2	10
141. Blue shale	1	1	0
142. Coal	0	0	5
143. Rock	1	1	9
144. Blue metal	4	2	0
145. Dark shale	1	1	2
146. Fire-clay	1	2	10
147. Blue metal and rock-band	2	2	6
148. Dark metal	2	0	6
149. Black shale	0	1	3
150. Coal	1	1	4
151. Stony warrant	2	1	4
152. Dark-blue shale	3	2	4
153. Black shale	2	1	1
154. Fire-clay	1	2	8
155. Blue metal	3	2	4
155. Dark blue metal	4	0	4
156. Inferior coal (good coal, 10 inches)	1	0	2
157. Strong warrant	1	1	6
158. Rock with cank-beds	4	0	5
159. Blue metal	2	0	0
160. Shale and coal	0	1	0
161. Fire-clay	1	2	0
162. Shaly coal	0	1	0
163. Rock	3	2	0
164. Blue metal	2	1	5
165. Black shale	4	2	0
166. Coal	0	2	8
167. Stony warrant	1	1	8
168. Rock-bands and grey layers	1	1	6
169. Blue metal and ironstone-balls	4	2	0
170. Black shale	0	0	11

		yds.	ft.	in.
171.	Soft coal	0	1	6
172.	Light fire-clay	0	1	4
173.	Shale and coal	0	1	0
174.	Stony warrant	0	2	6
175.	Blue metal (balls of ironstone)	11	1	0
176.	Strong rock-bands	1	2	2
177.	Coal (inferior)	0	2	1
178.	Dark warrant	0	1	4
179.	Strong rock-bands	1	2	0
180.	Blue metal	1	1	1
181.	Black shale	0	1	4
182.	Coal	0	0	6
183.	Dark warrant	0	1	8
184.	Rock with grey layers	2	0	2
185.	Blue metal	0	1	10
186.	Grey layers	1	0	7
187.	Black shale	0	2	7
188.	Blue metal	1	1	0
189.	Black shale	0	1	3
190.	Strong blue metal	1	0	6
191.	Rock (very hard stone, 4 ft. 6 in.)	4	2	9
192.	Blue metal (ironstone-bands, 3 in., 2 in., 3 in.)	2	2	9
193.	Dark shale	0	2	6
194.	Blue metal (balls of ironstone)	0	1	2
195.	Black shale	1	1	6
196.	Coal	0	0	6
197.	Warrant	0	0	7
198.	COAL	0	2	7
199.	Dark warrant	2	0	7
200.	Light rock	3	2	7
201.	Blue metal	4	3	0
202.	Shell-bed	0	0	2
203.	Soft blue metal	1	1	0
204.	Black shale	0	1	1
205.	Blue metal	1	1	7
206.	Black shale	0	0	3
207.	Light warrant	1	2	2
208.	Soft blue metal	2	2	6
209.	Dark warrant	1	0	5
210.	Strong blue metal	4	2	5
211.	Black shale	0	1	2
212.	Blue metal	0	1	7
213.	Rock-band	0	1	4
214.	Blue metal	0	2	8
215.	Dark shale	1	1	2
216.	Black shale	0	1	6
217.	Blue metal	1	2	5
218.	Coal	0	1	4
219.	Soft warrant	0	2	2
220.	Blue metal	4	0	4
221.	Black shale	0	1	4
222.	Strong warrant	1	0	3
223.	Grey layers	0	2	8
224.	Strong rock	1	1	8
225.	Blue metal and rock-bands	0	2	6
226.	Soft blue metal	1	0	0
227.	Dark metal	6	0	2
228.	Dark-blue metal	5	0	0
229.	Black shale (ironstone, 4 inches)	0	2	4
230.	Blue metal (at top, ironstone 3 inches)	2	1	6
231.	Black shale	0	1	2
232.	Blue metal	1	0	3
233.	Dark shale	1	0	0
234.	Strong blue metal	4	1	3
235.	Hard cank	0	0	11
236.	Strong grey layers	2	2	8
237.	Rock	2	1	8
238.	Blue metal	0	0	10
239.	Rock	5	2	0
240.	Coal	0	0	7
241.	Soft warrant	0	1	0
242.	Dark metal	4	2	7
243.	TOP HARD COAL	1	0	10
244.	Dark warrant	0	0	3

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2. *Notes on the* GEOLOGY *of* VICTORIA. By A. R. C. SELWYN, Esq.

(In a letter, dated Geological Survey Office, Melbourne, 14th Feb. 1859, to Sir R. I. Murchison, F.R.S., F.G.S., &c.)

RESPECTING the impoverishment of gold-bearing quartz-veins in depth, the only evidence I have been able to obtain of such being the case in this country consists solely in the great richness of the older drifts, and the very large lumps of the precious metal so frequently found in them, and never, or very rarely, in the solid unmoved quartz-vein. A 13 lb. and a 12 oz. "nugget" are, so far as I can learn, the largest pieces of solid gold ever known to have been procured *from a vein* in Victoria. From about ½ a dwt. to

$\frac{1}{2}$ an oz. is the usual limit to the size of "nuggets" even in the richest veins (such as have yielded, on crushing, from 5 to 30 oz. to the ton of quartz), whereas there does not appear to be any limit to the size of the lumps found in the drifts. This is an undoubted fact, and apparently a very strong argument in favour of the upper, now denuded, portions of the "reefs" having been much richer than anything we ever find either on or beneath the present surface. At the same time I must add that I am unable myself to discover, neither have I ever heard, any satisfactory explanation of this peculiar distribution of the precious metal in the quartz-veins. The very frequent intimate mixture of gold, both chemically and mechanically, with other metalliferous ores and native metals in the same vein or "quartz-reef," seems to me to preclude the supposition of a force having operated in the distribution of gold entirely different from that which has operated in the distribution of the other metals and metalliferous ores which we now find associated with the gold; and it seems to me very difficult to believe that the position of the gold, as we now find it, in the solid "quartz-reefs," and sometimes completely enveloped in crystalline quartz, is entirely due to sublimation; on this supposition alone, however, I imagine, could the superior richness of the upper portions of the veins be satisfactorily explained. In what state was the quartz when the gold was sublimed into it? and how is it that we find no evidence whatever of the action of such an intense and long-continued heat on the slates and sandstones which are in immediate contact with the gold-bearing quartz? It certainly appears to me that the cause, whatever it may have been, which has operated in the formation and filling of mineral veins generally, whether of tin, lead, copper, silver, antimony, or any other mineral, has also operated in the formation and filling of our gold-quartz-veins, which are, so far as I can make out, whether as regards their mode of occurrence, physical structure, or mineral character, strictly analogous to all other mineral veins. I should be very glad to learn what is now the generally received opinion on the subject of the formation and filling of mineral veins.

Is it not possible that the large lumps of gold and the general richness of the older drifts might be accounted for, partly, by the enormous amount of natural crushing and washing of the quartz, and consequent concentration of the gold, which must have taken place during the deposit of our gold-drifts, and partly also by some combined chemical and mechanical action operating on the liberated gold in the drifts during the long-continued and violent volcanic eruptions of which we have such ample evidence during the later Pliocene period? From all I have seen in this country, I certainly think we must look for some other explanation of the occurrence of our big lumps of gold in the drifts, besides the superior richness of the denuded upper surfaces of the veins. Saline waters are very abundant in all our formations, and chlorides are the prevailing salts found in them.

By this mail I send you a copy of the 'Ballarat Star,' containing

a letter from my friend Mr. Bland, the manager of the Port Phillip Company. The figures there given show what can be done in gold-quartz-mining with efficient machinery and proper management. The Cluner Gold Mine is, I consider, the only mine at present in Victoria where the requisites indispensable for success in this branch of gold-mining are to be found. They have good management and efficient machinery, and it being on private property, they are not hampered by the very obstructive rules and regulations made by the Government and the local Mining Boards applicable to the Crown-lands. Since the date of Mr. Bland's letter the "reefs" have been cut in two tunnels at the respective depths of 200 and 230 feet; in one the reef is 6 feet thick, and in both the quartz contains as much gold as it did at the surface. At Maryborough, 400 feet has been reached with a similar result; but in almost every case the yield has been neither steadily increasing nor steadily diminishing, but fluctuating. There are also many instances of quartz-veins having contained no gold on the surface, and having proved remunerative when followed to greater depths.

I have no satisfactory evidence for supposing any of our gold-drifts to be older than Lower Pliocene. With the Paper above mentioned I have sent you a 'Handbook to Australasia,' recently published here. In the article on Geology you will see, by what I have said on this subject, that I think they are all of Pliocene and Post-Pliocene age, with enormous contemporaneous basaltic lava-flows. The divisions I am provisionally adopting for the tertiaries in the maps about to be published are as under:—

1. Alluvial............	Recent fluviatile deposits, &c.
2. Post-Pliocene ...	Upper Gold-drift (angular, with recent Unios), Raised beaches, and Estuary beds (the shells all recent).
3. Newer Pliocene...	Middle Gold-drift with bones (rounded) of living and extinct mammals, Flemington red Tertiaries, Marine (like the Red Crag).
4. Older Pliocene...	Lower Gold-drift (with pounded bones of living and extinct animals), Upper Brighton Tertiaries, Marine (Lignite-beds, with *Banksia*).
5. Miocene............	Corio Bay, Cape Otway Coast, Murray Basin, and Lower Brighton-beds. (All marine, with characteristic Miocene fossils.)
6. Eocene	East shore of Port Phillip, Muddy Creek, Hamilton, &c. (Blue clays, with selenite and characteristic Eocene fossils.)

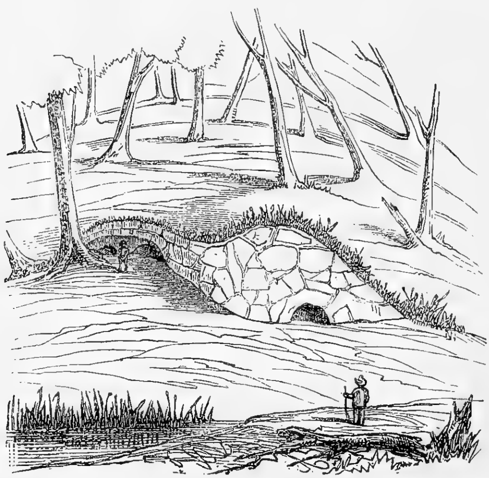
I have not yet been able to obtain any more satisfactory evidence respecting the probable age of our coal-bearing rocks: if the mass of them be Oolitic, there are certainly others in the eastern districts of the colony which contain true "Carboniferous" plants. So far as I could make out in Tasmania, the coal-bearing beds there rest quite conformably on, and pass downwards into, Calcareous beds, the fossils from which are, I believe, nearly all Carboniferous or Devonian forms. With the exception of a single specimen of a bivalve mollusk, I have not been able to find any fossil fauna in our coal-bearing beds.

In making use of the term "Cambro-Silurian," I did not mean to designate any true Lower Silurian beds, but simply to express a possibility of some of our oldest gold-bearing rocks being true Cambrian or Hypozoic strata. I have, however, found Lower Silurian fossils in the rocks of all the Gold-districts that I have carefully examined; but in any beds lying west of the meridian of Melbourne *Lingulæ* and *Graptolites* only have been found. We find Bohemian, British, and American species associated in both our Upper and Lower Silurian beds.

I have recently discovered, imbedded in our Pliocene water-worn gravel near Melbourne, two specimens, considered by M'Coy to belong to decidedly Chalk species. One is a very perfect Echinoderm, the other a fragment of Coral. They are both quite silicified and in about the same state of preservation. It will be very interesting if we can prove the former existence in Victoria of the Chalk-formation.

The only other interesting discovery of the Survey here is the Bone-cave at Gisborne, about 25 miles north of Melbourne. Enclosed is a sketch of the locality, also a plan and section on true scale from actual measured survey (see figs. 1, 2, & 3). In it, imbedded

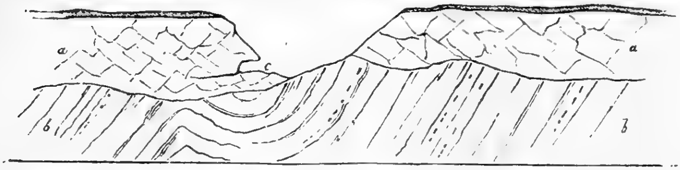
Fig. 1.—*Entrance of the Bone-cave in the Tertiary Basalt, in a Ravine at the head of the Toolerrn Toolerrne Creek, five miles S. by E. from Gisborne; explored by C. D. H. Aplin, Assistant-Surveyor,* 1857.



in light powdery and perfectly dry soil, we found great quantities of the osseous remains of Birds and Mammals; the most remarkable being perfect skulls of the Dingo, the Devil of Tasmania, and another carnivorous animal, which M'Coy thinks is quite a new genus: the skull is in shape somewhat similar to that of a domestic cat, but not more than half the size; and there are only two molars. The roof

and sides of the passages, where narrow, were quite smoothed and polished, evidently from the frequent passage of the animals that have inhabited the cave. When discovered, all these passages were so completely filled up with earthy matter, that no animal much

Fig. 2.—*Section of the Ravine and Cave.*



a. Tertiary basalt. *b*. Lower Silurian schists and sandstones. *c*. Mouth of Cave.

Fig. 3.—*Plan of the Bone-cave near Gisborne.*

larger than a rat could have obtained entrance; when cleared out, some of them were four feet high. The above would, I think, prove our basaltic lava-flows, in which the cave occurs, and which rest on the older gold-drifts, to be very old Pliocene. The bones are being figured and described by M'Coy.

I have sent you by this mail one of the first complete quarter-sheets of my Geological Map. I am getting them printed in colours from stone. I have now about twenty-eight such sheets ready for publication, forming together a connected map extending from Port Phillip Bay to Castlemaine.

With respect to the denudation of the Silurian rocks, I do not think there would be any great exaggeration in saying that thousands

of feet have been removed from probably the greater portion of the whole area which they now occupy; nor does this exceed Ramsay's estimate of the denudation of the Silurian rocks of South Wales, in his Paper in the first volume of the 'Memoirs of the Geological Survey of Great Britain.'

Our gold-drifts are often one, two, and three hundred feet thick (and this over very extended areas), completely filling up, with their contemporaneous lavas, nearly all the older valleys of the country.

June 15, 1859.

SPECIAL GENERAL MEETING.

It was resolved that persons proposed on and after November 2, 1859, for election as Non-resident Fellows of the Society, should pay an Entrance-fee of £6 6*s.*, and an Annual Subscription of £1 11*s.* 6*d.*

ORDINARY GENERAL MEETING.

Major W. E. Warrand, Bengal Engineers, Westhorpe, Southwell, Notts, was elected a Fellow.

The following communications were read:—

1. *Remarks on the* Geology *of* Spitzbergen.
By James Lamont, Esq., F.G.S.

In the summer of 1858 I passed a month cruising in my yacht around the shores of Spitzbergen and its many outlying inlets (or "skerries," as we should call them in the Highlands), and, although I have but a very slight knowledge of geology, still I was very much struck by the singular geological aspect of the country. As I visited a part of Spitzbergen which has never before been seen by any one except the ignorant seal-fishers who frequent the coast, I have been induced to commit a few of my observations to writing, in hope that others better acquainted with the theories of glacial action and upheaval of land may be able to understand the changes which are being brought about in those regions by the above agencies.

We first reached the shores of Spitzbergen, about 20 miles north of South Cape, and inside of what is known as Stour-fiord or Wybe Jan's Water, an immense sound of about 300 miles long, and varying from 6 to 60 miles broad. This Sound is improperly marked in the maps as a Gulf, whereas it is in reality a Sound, dividing Spitzbergen into two nearly equal halves; but the north end, being very narrow, is invariably almost choked with heavy ice, and, being consequently impassable, has given rise to that error: boats are known,

however, to have actually passed through from the north coast into Stour-fiord.

The first thirty or forty miles of coast along which we sailed consisted almost entirely of the faces of two or three enormous glaciers reaching high up into the mountains (the tops of which were barely visible in places peeping through the ice), with their bases reaching into the sea; of course every now and then large pieces, some of them as big as a church, become detached from these ice-precipices and topple into the sea with terrific uproar. The waters of this Sound are very shallow, seldom as much as sixteen fathoms; and I believe it is the same all round the shores of Spitzbergen, so that the formation of very large icebergs is impossible, and I saw none at all approaching to the size of those to be met with on the banks of Newfoundland: the largest of those which we did see were aground.

The greater part of the shores of this great Sound on both sides present a singular uniformity of contour. First, there is a muddy flat of from half a mile to three miles broad, extending from the sea to the foot of the lower hills: this plain is composed of mud mixed with shaly débris from the lower hills; it is generally in a semi-fluid state and almost impossible to walk over, but there is ice or hard ground at 12 to 18 inches under the surface. Many rivulets, thickly charged with mud, and some of them unfordable, intersect these dreary flats; they are sparingly clothed with small Saxifragas, mosses, and lichens, which form the food of the reindeer. These animals are tolerably abundant on the flats, or in the valleys not filled by glaciers, and attain to a most wonderful condition of obesity, considering the scantiness of their diet. On these flats are numerous trap-rocks, coming up like islands in the flats, and also prolonged dykes of trap. In some plains these approach to that singular formation known as the Giant's Causeway, but without its regularity.

At the end of the flat there is generally a steep slope of mud, snow, and shaly débris, which reaches up to the perpendicular crags of rock. This rock resembles a mixture of limestone and white sandstone, and is easily split and broken. These cliffs are generally quite inaccessible, and above them stretch for many miles away into the mists enormous glaciers, and above these again are visible, when the weather is clear, high peaks, apparently of granite, 6000 or 7000 feet high, from which Spitzbergen derives its name.

Along the shores of Stour-fiord, as far up as we went (we sailed up to where it was choked with ice and shallowed to three fathoms), there is a considerable quantity of drift-wood. This consists principally of small pine-trees, very much weather-worn and many quite water-logged. I also observed much wood which had formed part of vessels: some of this was oak. There are also everywhere to be found many bones of whales, occurring both singly and in nearly entire skeletons.

Many of these pieces of drift-wood and bones are lying several *miles inland* and *high above high-water mark*. I regret that I did not *measure* the height at which I saw any, but I am positive that

I saw both whales' bones and drift-wood *at least thirty feet*, and I think as much as forty feet, above high-water mark. Geologists can form their own deductions from this; but I may mention that the seal-fishers all believe the land to be rising, or, as they generally express it, " the sea is going back."

Whales used to be formerly very abundant around the shores and bays of Spitzbergen, but of late years the true whale (*Mysticetus*) is unknown within many miles of Spitzbergen. Macculloch and other commercial writers attribute this to the persecution they have undergone; but the seal- and walrus-fishers all say that "the seas have got too shallow for them." This may also arise partly from the enormous quantities of mud and débris brought down by the numerous rivulets running from the steep slopes of the mountains. Some of these rivulets have immense deltas of semifluid mud at their mouths.

The Thousand Islands are an immense cluster of low rocky islands lying off the south-east corner of Spitzbergen, and consist entirely (at least, as far as I could observe) of a coarse granular trap. They are mostly very low, and with very little soil on their surfaces. I observed the skeletons of whales upon some of them at such a height that it was quite impossible they could have been washed there with the rocks at their existing level; and this seems to me to afford conclusive evidence that Spitzbergen and the adjacent islands are emerging from the deep at a rate even more rapid than that at which the coasts of some parts of Norway have been clearly demonstrated by distinguished geological writers to be rising.

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2. *On the* Formation *of* Gypsums *and* Dolomites.

By T. Sterry Hunt, Esq., of the Geological Survey of Canada.

(Communicated by Professor Ramsay, F.R.S., F.G.S.)

The deposits of gypsum in nature may be divided into two classes. One of these comprises the gypsums formed by the alteration of beds of limestone. The vapours of solfataras, the sulphuric acid produced by the slow oxidation of moist sulphuretted hydrogen gas (as shown by Dumas), and springs containing free sulphuric acid are the agents which have changed and are still changing carbonate into sulphate of lime. Such springs, containing from $\frac{3}{1000}$ to $\frac{4}{1000}$ths of free sulphuric acid (evolved probably from the reaction between sulphate of lime and siliceous matters under the influence of heat at considerable depths), are frequent in Western Canada; and their effects in giving rise to masses of gypsum in the quaternary clays of that region I have long since pointed out (Rep. Geol. Survey of Canada, 1848, p. 155).

The gypsums of the second class, which are the more frequent, are met with interstratified with marls, dolomites, and rock-salt, with which they are evidently contemporaneous. Reserving for

another occasion the discussion of the theories which have been proposed to account for the origin and association of these substances, I propose to mention some recent observations of mine which serve to throw light upon the question.

When a solution of bicarbonate of lime in carbonic-acid water is mingled with one of sulphate of magnesia, there are formed sulphate of lime and bicarbonate of magnesia; so that in presence of an excess of bicarbonate of lime there is obtained a saturated solution of gypsum, from which this salt may be thrown down by the addition of alcohol.

In the same way I have found that a solution of sulphate of soda is decomposed by bicarbonate of lime, whose solubility in water is much augmented by the presence of the alkaline sulphate. From such a solution the addition of alcohol precipitates gypsum, leaving bicarbonate of soda in solution.

When a mixed solution of sulphate of magnesia and bicarbonate of lime is evaporated at a gentle heat (from 80° to 120° F.), the gypsum, being much less soluble than the bicarbonate of magnesia, is first deposited in a crystalline form, and at a later period the magnesia separates as a hydrous carbonate. The presence of sea-salt does not prevent this reaction, nor the precipitation of gypsum by evaporation; so that by continued additions of bicarbonate of lime to a basin of sea-water, its sulphate of magnesia might at length, under favourable conditions, be entirely converted into gypsum.

The hydrated carbonate of magnesia deposited from solutions of the bicarbonate is very soluble in dilute acids; but when heated to 300°–400° F. under pressure to prevent the escape of carbonic acid, it is converted into a crystalline, anhydrous, and difficultly soluble carbonate, already obtained by De Senarmont, and apparently identical with magnesite. When the hydrous carbonate is thus heated in presence of carbonate of lime, the two combine to form a double carbonate, which, by taking advantage of its sparing solubility in cold dilute acetic acid, may be separated from any admixture of free carbonate of lime. This double carbonate of lime and magnesia is dolomite. As prepared under various conditions, I found it to contain from 35 to 45 per cent. of carbonate of lime, the excess of magnesia being due apparently to a variable admixture of magnesite. Its formation by the direct union of the carbonates of lime and magnesia takes place alike in the presence of solutions of earthy chlorides and alkaline carbonates. In Von Morlot's experiment, however, which consists in heating a mixture of two equivalents of carbonate of lime and one of sulphate of magnesia in sealed tubes to 200° C., the sulphate of lime which is formed seems to prevent the union of the two carbonates, and the product I have found to be chiefly magnesite mixed with carbonate of lime. In Marignac's experiment, where chloride of magnesium is substituted for the sulphate, the newly formed carbonate of magnesia unites with the carbonate of lime, and a portion of dolomite is formed.

But the solutions of bicarbonate of magnesia which give rise to deposits of hydrous carbonate of magnesia, that, according as they

are pure or mingled with carbonate of lime, are subsequently converted into magnesite or magnesian limestone, may also be formed by another reaction, which is independent of the formation of sulphate of lime. I have already alluded to it, in my paper "On some points in Chemical Geology," read before this Society on the 5th of January last. Waters holding in solution bicarbonate of soda (a constant product of the decomposition of felspathic minerals), when mingled with sea-water, decompose the lime-salts first, the carbonate of lime separating in a nearly pure state; so that in lakes and limited sea-basins there must result from this reaction waters that, like the bitterns from which all the lime has been removed by evaporation as sulphate (another source of gypsum), contain only salts of soda and magnesia. The further action of solutions of bicarbonate of soda upon such magnesian waters must give rise to bicarbonate of magnesia, and, aided by evaporation, to precipitates of magnesian carbonate—which, mingled with the carbonate of lime generally accompanying the bicarbonate of soda in alkaline waters, would afford the material for those great beds of magnesian limestone which are independent of gypsum. (See Proc. Royal Soc. for May 18, 1858; Phil. Mag. vol. xvi. p. 379.)

The points to which I wish to call attention in the present note are, first, the formation of sulphate of lime and bicarbonate of magnesia by the action of bicarbonate of lime upon a solution of sulphate of magnesia, and their successive deposition in the forms of gypsum and hydrous carbonate of magnesia during the process of evaporation; and secondly, the direct union, under certain conditions, of this carbonate of magnesia with carbonate of lime to form a double carbonate, which is dolomite.

The application of these reactions to explain the formation of dolomites and a great portion of the gypsums, both in marine and freshwater deposits, will readily be made. The details of my experiments will be found in part in the Report of the Geological Survey of Canada for 1857*, and completed in the forthcoming Report for 1858.

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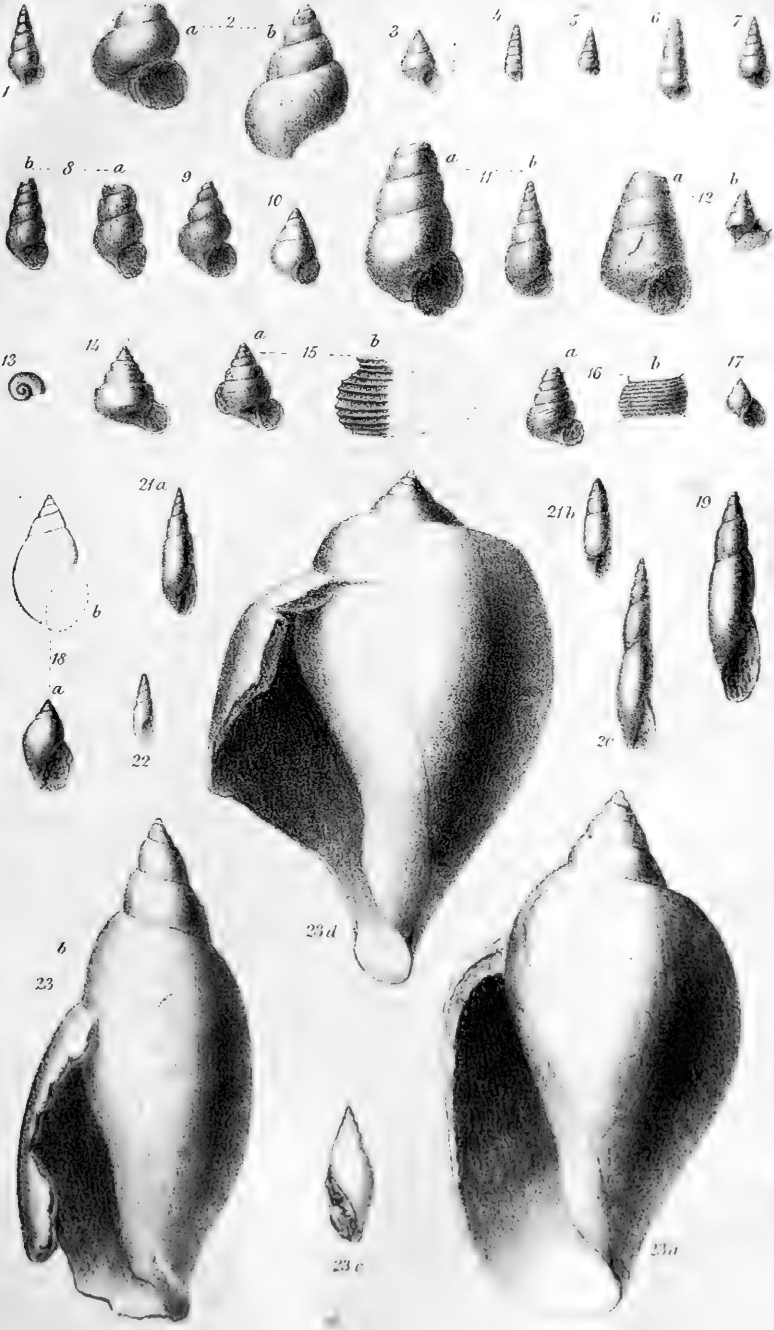
3. *On the* Tertiary Deposits, *associated with* Trap-rock, *in the* East Indies. By the Rev. Stephen Hislop. *With* Descriptions *of the* Fossil Shells, by the Rev. S. Hislop; *and of the* Fossil Insects, by Andrew Murray, Esq., F.R.S.E.; *and a Note on the* Fossil Cypridæ, by T. Rupert Jones, Esq., F.G.S.

[Communicated by the President.]

(Plates V.—X.)

In introducing the following descriptions of some fossils from Peninsular India, I shall confine my remarks to the rocks, volcanic

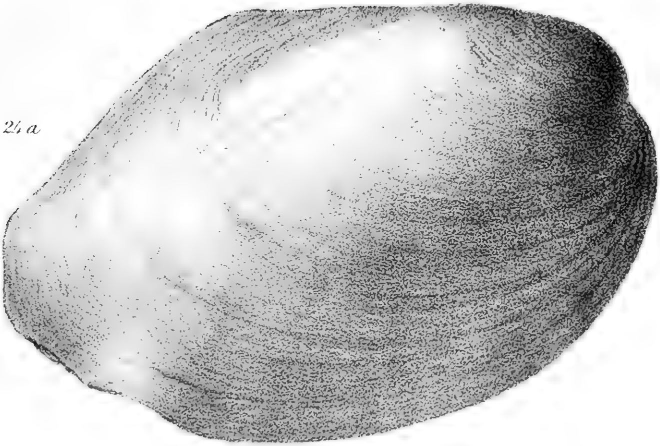
* See also Am. Journ. Science, 2nd ser. vol. xxvi. p. 109.



TERTIARY SHELL

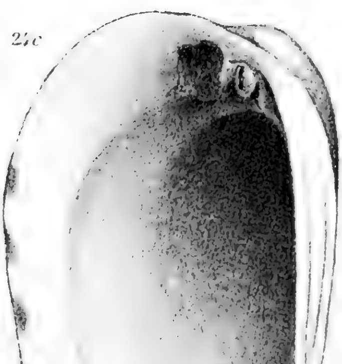
S. Hislop & G. West del.

24 a



24 b

24 c



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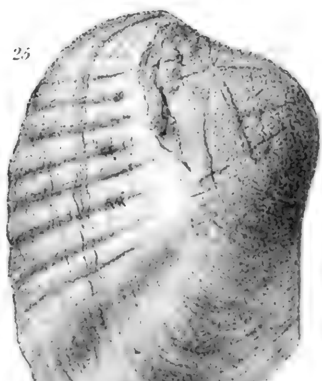
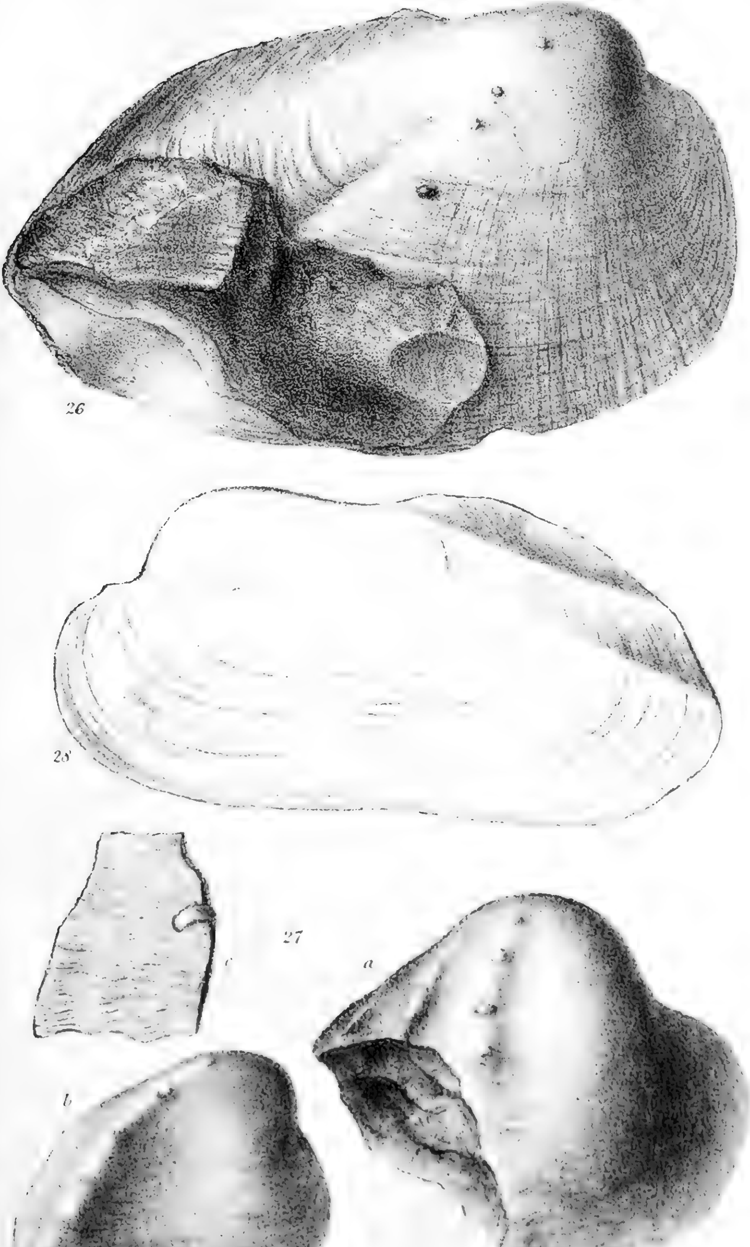
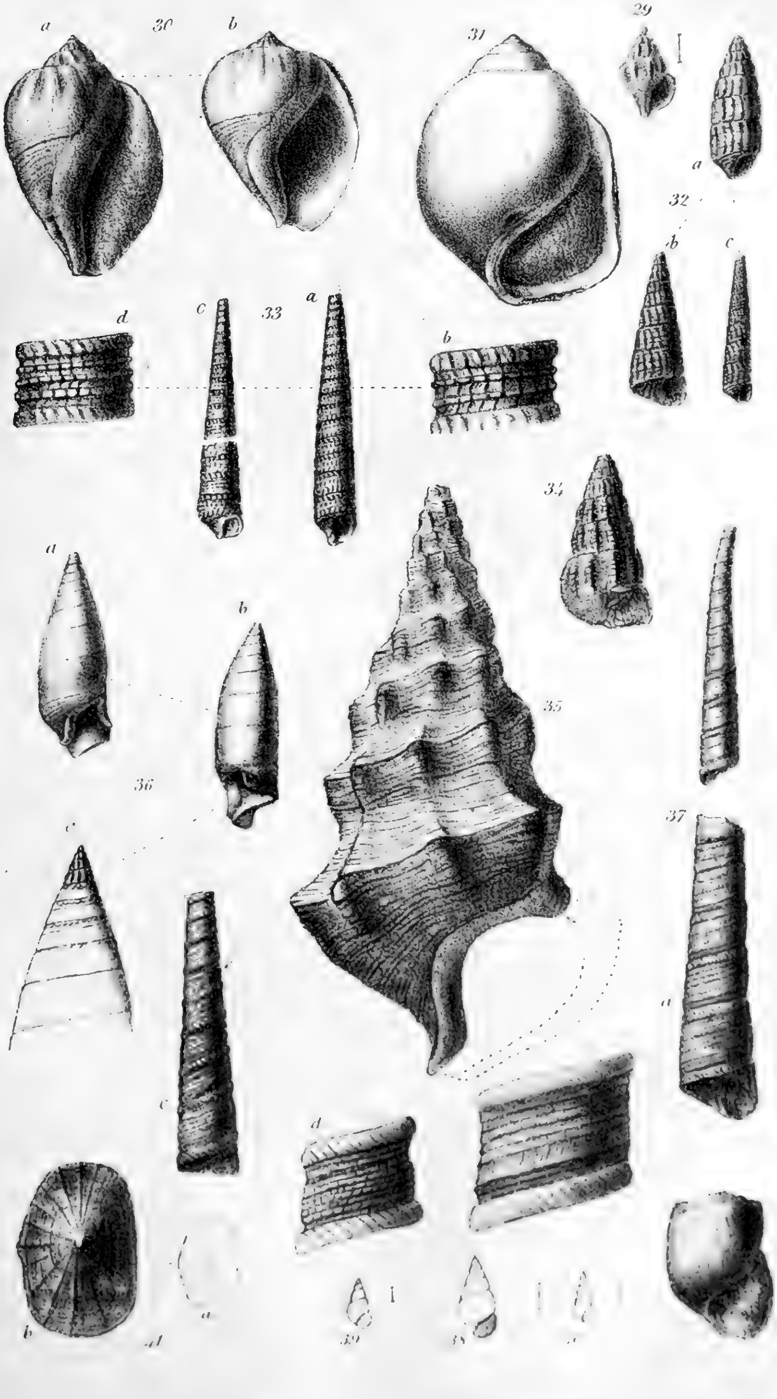


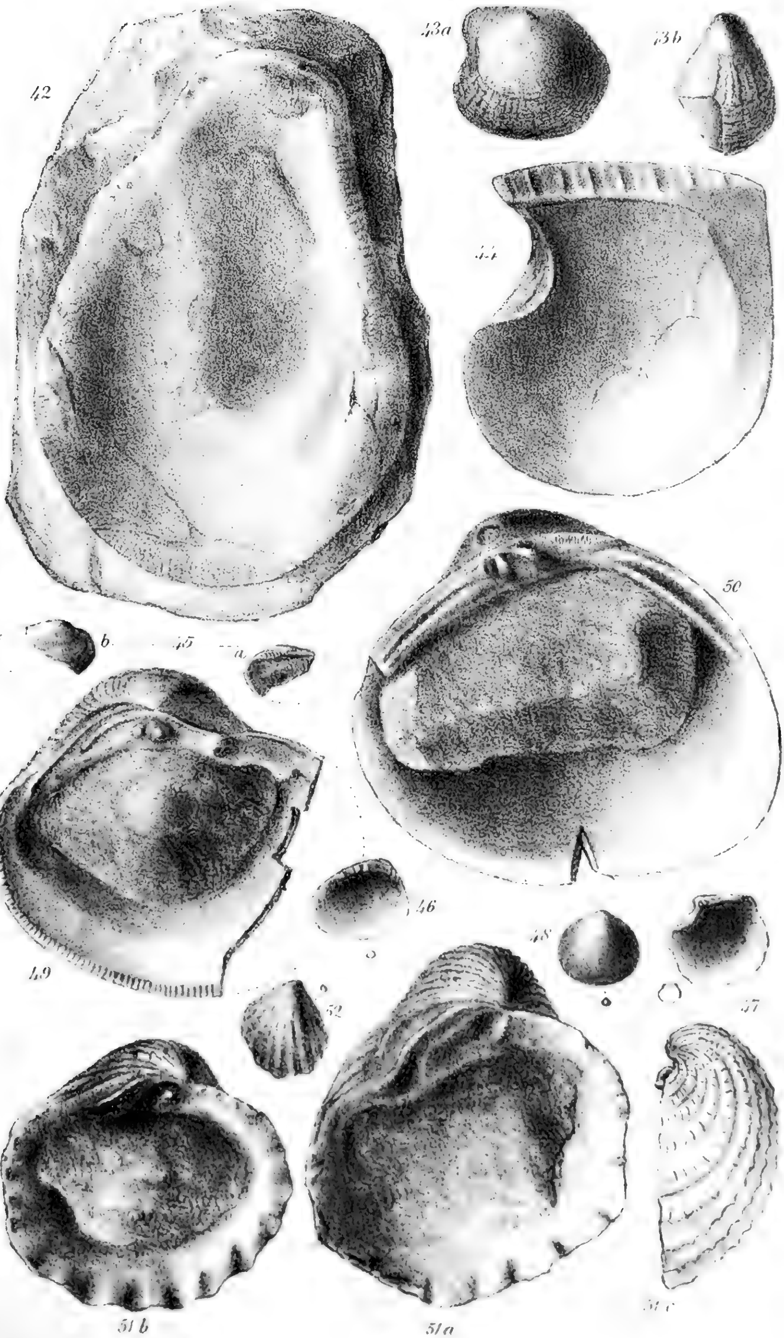


TERTIARY SHELLS NAGPUR

S. Hislop & G. West del.   W. West imp.



TERTIARY SHELLS RAJAMAHL



TERTIARY SHELLS RAJAMANDRI

TERTIARY SHELLS, INSECTS, & CYPRIDES RAJAMANDRI, NARBADDA, & NAGPUR

S. Hislop, A. Murray & G. West del. W. West imp.

and sedimentary, with which those fossils are connected. They have already been noticed in a memoir, which, in conjunction with my friend the Rev. R. Hunter, I submitted to the Society in 1854*.

On that occasion I endeavoured to prove that there was no foundation "for the supposition that the great outpouring of basalt in India took place in the ocean,"—that the water of the lake in which it really was effused was in many places "so shallow as to allow the igneous rock to rise above its surface into the atmosphere," and that therefore the flatness of the tops of trap-hills was not owing to superincumbent pressure, as is generally believed, but was "the effect of the well-known law by which the surface of liquid bodies is reduced to the same uniform level." The age of the deposit formed at the bottom of the lake, before it was invaded by the volcanic eruption, I considered to be Lower Eocene; and, while inferring as a matter of course that the overlying trap was subsequent to it, I expressed the opinion that the similar rock which was frequently found underlying was more recent than both.

In opposition to this last view it is held, that the underlying trap must have been poured out first, and the freshwater deposit formed over it. This, I admit, would be the theory attended with the fewest general difficulties; but the objection to it in my opinion is, that it does not apply to the case under consideration. If it did, we should expect that, at the junction of the deposit with the subjacent amygdaloid, the former would partake of the colour of the latter, whereas there is most frequently a marked difference between them in that respect. In fact, instead of the deposit being composed of the detritus of the friable amygdaloid, I believe it will be found, on the contrary, that the friable amygdaloid consists in a great measure of materials altered from the deposit. Capt. Newbold's analysis of amygdaloid underlying red clay warrants this statement, though he does not seem to have perceived the inference deducible from it regarding the relative age of the vesicular trap †.

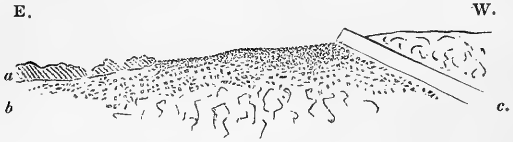
But should this chemical proof not be enough, there is mechanical evidence at hand. About two miles to the west of Telankhe*d*i, and five in the same direction from Nágpur, we have a natural

* Quart. Journ. Geol. Soc. vol. x. p. 470; vol. xi. p. 345, & p. 555, with Map.

† See Journal R. Asiat. Soc. vol. ix. p. 35, where Newbold says: "I found the basis of the amygdaloid in which zeolitic crystals were most abundant to be a red clay." The import of this remark will be best brought out by a reference to the Sindaghi section alluded to in another part of this paper. In that section between the middle and upper seam of kunker there is represented in the woodcut a considerable thickness of "red amygdaloid with zeolites and calc-spar," and it is added in the letter-press, "In this vicinity beds from three to six feet thick occur in the amygdaloid of a finely laminar, bright red bole." Now, looking at the figure, in which the calcareous matter is so thin that it is represented only as seams, we naturally feel disposed to ask, Where is the deposit, which in the "vicinity" attains a thickness of "from three to six feet"? The only appropriate reply to this question, in my judgment, is, that it is to be found in the red and brownish-green amygdaloid, which, though still retaining its colour, has been transformed from the clay, while the calcareous portion has been segregated in the process.—S. H., June 22, 1859.

section of this sort. (See fig. 1.) Here, in going westward, the eye is attracted first of all by some blocks of yellowish rock lying in

Fig. 1.—*Section near Telankhedi.*



a. Altered Freshwater-rock. *b.* Trap-rock. *c.* Freshwater-rock.

position on the surface. Externally they exhibit marks of *Physa Prinsepii,* and on being broken they are discovered to be a crystalline mass in the centre. Doubtless this metamorphosis is due to the heat communicated by the trap in its former state of lava, which, being longer retained in the interior of the blocks, subjected the particles there to a decided change, while those on the outside remained unaffected. As you pass on, you walk over trap till you arrive again at the freshwater stratum, which in an adjoining watercourse is seen to sink down to the west at an angle of about 30°, with soft amygdaloid below it, and a less vesicular rock above. It is evident that at this spot we have an anticlinal axis on a small scale, and that the cause of the disturbance is the volcanic rock, which, whether it lies below or above, must be subsequent to the deposit. My lamented friend Adolphe Schlagintweit, who held that the lower trap was prior to the deposit, felt constrained to admit, in order to account for the appearances presented at the junction of the two, that occasional showers of volcanic ashes may have continued to fall during the formation of the aqueous rocks *; but I see not how volcanic ashes could fracture and upheave the latter, as we find to be the case: and, supposing the ejection of these ashes to be attended with the dislocation of the stratum, it is difficult to understand how the underlying amygdaloid could rise as a boss into the upheaved portion, unless it were in a liquid state after the deposition of the upper rock.

Again, between the spot now referred to and Nágpur there is a ravine displaying a natural section somewhat like the subjoined †.

* Report VI. of the Magnetic Survey of India, p. 34.

† See Journal R. Asiat. Soc. vol. ix. p. 33 for a similar section given by Newbold from a trap-hill near Sindaghi, in the southern Maráthi country. There we have in descending order: globular concentric basalt; a seam of kunker; red amygdaloid with zeolites and calc-spar; another seam of kunker; wacké, brownish-green and grey; and a third kunkeraceous seam, which is underlaid by wacké. The three kunkeraceous seams are represented as connected with each other in the same manner as in the above section. In designating these seams I use the term employed by Newbold. Of course they have nothing to do with "kunker" commonly so called in India, which is a comparatively recent concretion in the soil of the East. They are in fact the calcareous matter of the intertrappean

Here we see nodular trap of about 14 feet thick in the central and more remote part of the sketch, overlying the freshwater de-

Fig. 2.—*Section in a ravine between Telankhedi and Nágpur.*

a. Nodular trap-rock; from 4 to 14 feet thick.
b. Freshwater-rock; 1 to 3 feet thick.
c. Amygdaloidal trap, with interspersed bands of altered freshwater-rock.

posit, the top of which only is visible, and which extends 3 feet downwards without interruption. In the foreground on the left bank of the stream, or on the spectator's right hand, the same trap reaches no greater thickness than 4 feet, while the sedimentary rock on which it rests is less than a foot thick, the remainder being dispersed in the form of pale bands, sometimes running into each other, through the body of the volcanic rock, which in these circumstances has assumed chiefly a soft vesicular structure. An examination of this spot would, I think, suffice to convince any geologist that the trap in its amygdaloidal form must have been the instrument of this scattering of the deposit, and that consequently it must have been injected after the deposit accumulated at the bottom of the lake.

Whether the amygdaloid is a subsequent eruption to the nodular trap, as I once supposed, is not so certain. All that the phenomena which I have observed show, is that it was probably liquid after the nodular part was consolidated; and this may have been the case in consequence of the upper portion of the lava cooling first, although both it and the lower portion were erupted at the same time. To illustrate this I subjoin a third section exhibiting the relation of the rocks lying in a line drawn from the Artillery Lines of Tákli south to the Nág River.

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deposit, the upper part of it probably remaining in its original position immediately under the "globular concentric basalt," and the rest being dispersed by the volcanic rock, as in our section. Sometimes the seams originating from this deposit are more clayey and siliceous in their character, and then we have an abundance of jasper, bloodstone, or cherty flint.—S. H., June 22, 1859.

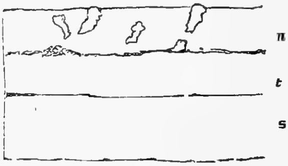
On the north, at the Artillery Lines, the rocks in a descending order are: *n*, nodular trap; *t*, tertiary deposit, thin and indurated in the

Fig. 3.—*Section at the Artillery Lines, Takli.*

n. Nodular trap-rock.
t. Tertiary deposits.
a. Amygdaloidal trap.
s. Sandstone.
p. Pegmatite.
gn. Gneiss.

higher position, and thick and soft in the lower; *a*, amygdaloid, and *s*, sandstone. On the south near the river we find: *s*, the same sandstone; *p*, pegmatite, and *gn*, gneiss. For the sake of clearness I enlarge the section of the rocks on which the Artillery Lines are built (fig. 4). Here, as before, *n* is nodular trap; *t*, tertiary stratum,

Fig. 4.—*The strata at Artillery Lines.*



n. Nodular trap. *t.* Tertiary beds. *s.* Sandstone.

clayey and soft, and *s*, sandstone. From the argillaceous deposit portions have been taken up into the body of the volcanic rock, and sometimes as high as its surface. Such detached fragments have furnished us with the greater number of the vegetable remains for which Tákli is remarkable. Where the trap comes into contact with the base of these masses, it is seen not to be nodular, as it is everywhere else, but vesicular.

Now the question arises, Is the thinner and harder deposit on the slope of the hill in fig. 3 the same as the thicker and softer stratum at the lower level of the Artillery Lines? I have no hesitation in affirming that it is; for in digging through the hill, no deposit but it is met with until the sandstone is reached,—not to mention that the same genera and species of shells are obtained from both. Now as in fig. 4 the single layer of lava has become vesicular or nodular according as it lies below or above the detached pieces of the clayey deposit, so we have only to suppose that part of the same lava-flow at the present site of the hill in fig. 3 went above, and part found its way at the bottom of the deposit, and we discover the reason of the upper trap being nodular and the lower vesicular. The origin of the vesicles in the lower trap would appear to be the exudation of moisture from the stratum under which it was intruded; while

the cause of the greater accumulation of lava at the spot where the hill now stands may perhaps have been the delay resulting from the effort requisite to break through the deposit and flow along its base. And as in its onward course the lava would transform some of the deposit, we can understand how the intertrappean stratum of the hill is thinner than the subtrappean stratum of the plain, and can moreover perceive how it is that the igneous at its junction with the aqueous rock is to such an extent composed of the same materials as the latter. Preferring, though I do, this theory of the eruption of our trap, I would at the same time here beg to repeat the remark previously made, viz. that although both the upper and the lower portion of it were poured out together, still the lower would probably continue, after the upper was consolidated, sufficiently liquid to be capable of breaking up both the deposit and its incumbent sheet of trap, as represented in fig. 1.

The sandstone, which lies conformably under the clay at the Artillery Lines (see figs. 3 & 4), is the same as extends northward through the plain to Godni Bhokárá, where it is hard enough to be quarried, and the same as attains to the immense thickness witnessed on the lofty mural crags of the Mahádewa Hills. Lying, however, in our district as conformably above the Glossopteris-sandstone and coal-beds as it does below the clay, I was inclined to class it with the former rather than the latter. I am now convinced that it is to the era of the latter that it belongs. Like most arenaceous deposits, it is comparatively destitute of organic remains. In our Memoir of 1854 I noticed stems of trees as imbedded in it. These are very numerous in a ferruginous state at Silewádá, and in a silicified condition near Chándá, as also further south in the basin of the Pranhítá. In sinking a well through Sitábaldi Hill they were met with in a third form, viz. like lumps of charcoal. But along with these stems there was found in the same shaft a little *Paludina*, which, on being kindly forwarded to me by Captain Cadell, of the Bengal Engineers, I could not distinguish from one common in the clayey deposit. I was now persuaded that the upper sandstone was not to be classed with the lower, but with the Physa-bed; and, while perceiving my former mistake on this point, I beheld a confirmation of a view that I had previously expressed, to the effect that all the deposits now remaining around Nágpur, from the fern-strata upwards, were of freshwater origin.

This discovery having brought the upper sandstone within the scope of this paper in consequence of its connexion with the Physa-bed, it has for the same reason rendered it necessary here to refer to the metamorphic rocks near Sitábaldi Hill, for these are but the upper sandstone transformed. In passing over the outcrop of gneiss, which extends eastward from the base of that double-topped knoll to the city of Nágpur, a superficial observer, seeing the apparent dip at a high angle to the south, might suppose that he has before him very ancient strata; but let him find a spot where the sandstone and gneiss come together, and he will discover that the one gradually changes into the other, and the almost horizontal direction of the

stratification imperceptibly passes into the high inclination of the slaty cleavage. It is the neighbourhood of some plutonic rock, of which we have evidences in the numerous veins of pegmatite running through the gneiss, that has effected the metamorphosis.

Having said thus much about the mutual relations of these rocks, I have now to make some general observations on their contents, both mineral and organic.

I. *Minerals.*—These have been ably described by the Rev. Professor Haughton in a paper read before the Royal Dublin Society in November of the past year, and published in the 'Philosophical Magazine' for January last. I shall notice only those that are more important, and that obviously belong to the rocks at present under our consideration.

In the trap at the Tákli Artillery Lines, which encloses pieces of the clayey fossiliferous deposit (see figs. 3 & 4), there are also contained masses of "calc-spar curiously striated, the lines of growth not being perpendicular to the optic axis, but formed by planes parallel to one of the edges of the obtuse trihedral angle of the rhombohedron, and intercepting equal portions on the other two edges of that angle." The doleritic lava, which is quarried from Sitábaldi Hill, and which answers to the lower trap of fig. 3, is in some places marked with belts, that may be traced continuously for many yards, consisting of cavities "lined with obsidian in a thin glazed pellicle, and occasionally filled up with tabular crystals of calc-spar." In the trap on the south escarpment of the hill represented in fig. 3, there was discovered a rhomboidal piece of a green mineral, which Professor Haughton proposes calling *Hislopite*, being in his opinion worthy of distinction as a new species from the remarkable combination in it of calcareous matter, which gives the outward form to the whole crystal, with a grass-green siliceous skeleton of glauconite, which on analysis he finds to be a hydrated tersilicate of protoxide of iron, or in more technical form:

$$\left.\begin{matrix} 3\,\mathrm{RO} \\ \mathrm{Al}^2\,\mathrm{O}^3 \end{matrix}\right\} 3\,\mathrm{Si}\,\mathrm{O}^3 + 3\,\mathrm{HO}.$$

Our trappean minerals, however, are few and worthless, compared with the varied and magnificent assortments at present procurable in the Western Ghats between Bombay and Puná. In a letter received a few days ago from my friend Mr. Carter I am told, that the tunnel now being carried through the Bore Ghat lays open geodes frequently as large as grottos, the sides of which are covered with every variety of zeolitic and siliceous mineral to be found in trap.

At Gi*dad*, and at Pánjrá near the Pench River a little above its junction with the Kolbairá, there are found, in the red clayey tertiary deposit of the fields, "radiated concretionary nodules of brown carbonate of lime and iron." These being supposed to be peculiar to the first-mentioned locality were craftily taken advantage of by some *fakírs* residing there to found on them a story about the wonder-working powers of their master. It rather spoils the credit of this fable to fall in with the same supposed petrified fruits in another

part of the province, where their master is never pretended to have been.

From a vein of pegmatite in gneiss a few hundred yards east of my house a fragment was broken off, which, besides the usual components of quartz and felspar, contained a "white felspathic mineral of fatty lustre, softer than felspar, but gritty under the agate pestle." To this mineral Prof. Haughton has given the name of *Hunterite*. Neglecting the lime and magnesia in it, which are inconsiderable, it is found to consist "of five atoms of a hydrated tersilicate of alumina combined with one atom of a hyaline silica of admitted composition," or

$$5\,[Al^2\,O^3,\,3\,Si\,O^3+3\,HO]+[HO,\,3\,Si\,O^3].$$

II. *Fossils.*—Almost all the discoveries of organic remains that have been made since 1854 in the tertiary deposit have been beyond the limits of our province.

In addition to the list of fossiliferous localities given on pp. 362, 363, vol. xi. of the 'Quarterly Journal,' I would mention the following sites for shells in the Hyderabad country: Dhánki, 10 miles E. of Umarkhe*d* or 150 S.W. from Nágpur; Kuntur, about 20 miles S.E. of Nánder or 40 farther S.W. from Nágpur than Dhánki; A'mbiá Kanti and Tándrá near Olá or Olám, about 20 miles W. of Nirmal and 160 S.S.W. of Nágpur; Májájonna, 20 miles W. of Khair or 95 S.S.W. of Nágpur; Dálmettá Ghat near Kondápur, 12 miles S.E. of Mánikga*d* or 120 miles S. of Nágpur; and Wilipítá and Yidalawá*d*á on N. of Tá*d*ur (in maps Tandoor), about 25 miles S.S.E. of Dálmettá Ghat. At most of these places only the more common shells are found. But from two other localities in the Hyderabad Territory, Kárúni and Mekalgandi Ghat, the latter of which was visited by Malcolmson, I have received several new species of *Unio*.

The most important accession, however, to our collection of shells has been from a part of India still farther distant from Nágpur. In the volume of the 'Quarterly Journal' above referred to, I stated that I had been favoured by my friend Lieut. Stoddard with a few shells partly freshwater and partly marine from the neighbourhood of Rájámandri*. The hills from which these were obtained are 5 miles S.W. of Panga*d*i, a village 10 miles W. of Rájámandri on the road to Madras. They reach an elevation of about 300 or 400 feet above the level of the plain. At their base lies a red conglomeratic sandstone, over which there is a considerable thickness of trap, compact below and becoming more vesicular above, where it imbeds veins of jasper. This is surmounted by a deposit of impure limestone, the upper part of which, containing the most and the best of the estuarine fossils, protrudes from the slope in a layer of 1½ feet

* Quart. Journ. vol. xi. p. 365. In a footnote a conjecture was thrown out, whether one of the marine shells might not be a *Nerinæa*—a hypothesis, which, if true, would imply a much greater antiquity for our intertrappean deposit than I have ever been willing to ascribe to it. But there can be no doubt that the shell in question was a *Turritella*.

thick, from which blocks have been carried down into the water-courses below. The top of the hill consists of nodular basalt. I need not point out the resemblance which this locality, as described by Benza, bears to a trap escarpment in the vicinity of Nágpur. In the position of the sandstone and the shell-deposit, of the nodular and the vesicular trap, including even the jaspideous and cherty veins running through the latter, the two fossil sites are identical. It is only in the fossils that any difference can be recognized. In the one place they are lacustrine, in the other estuarine. Yet even among the organic remains, as if to leave no doubt of the perfect contemporaneousness of the two formations, there are species common to both.

A similar outlier of trap has recently been brought to the notice of the scientific world by the Hon. Walter Elliot at Káteru, 2 miles N. of Rájámandri. About 400 or 500 yards from this hill quarries have been opened, and the following section displayed: Black soil 3 feet; trap-rock disintegrating 5 ft.; deposit 6 ft. 9 in., consisting of limestone with shells 1 ft.; clay and gravel, and yellow clay and sand 11 in.; limestone 1 ft.; clay and sand 4 in., which again is underlain by a third layer of limestone of the same thickness as the other two, resting on 2 ft. 4 in. of clay shale, white, yellow, purple, &c. Under the deposit basalt with zeolites was penetrated to the depth of 14 feet. The following is another section nearer the hill: Basalt $12\frac{1}{2}$ ft.; greenish unctuous indurated clay 2 ft. 8 in.; fibrous limestone $1\frac{1}{2}$ in.; highly crystallized limestone 3 ft., below which was basalt. In a third excavation the deposit was considerably thicker, being made up of a greyish friable clay with shells 9 ft. 9 in., more compact clay with larger shells 10 ft. with a base of crystallized limestone as before. The crystallization of this limestone would seem to be due to the underlying basalt, which on that supposition must have been in a molten state subsequent to the deposition of the calcareous bed, as I have endeavoured to prove in regard to the rocks of Central India. The same inference is suggested by the jasper at Panga*d*i, which occurs there, as at Nágpur, in the soft amygdaloid immediately underneath the deposit, and is evidently just a portion of the latter detached by intruding lava. None of the quarries at Káteru seem to have been carried through the lower basalt down to the sandstone; but that arenaceous beds are present may be warrantably concluded from their cropping out on the hill at Dowleshwaram 4 miles S. of Rájámandri. For all my specimens from Káteru I am indebted to the kindness of Capt. Stoddard of the Madras Public Works Department, the same friend who examined the Panga*d*i Hills for me on the former occasion.

The few palæontological discoveries which have been made within our own province have been in the south of it, not far from Mángali, the well-known locality for fossils of the sandstone.

At Dongargaum, which is 14 miles a little E. of S. from Mángali, there is an outlier of the trap, from under which come out yellow calcareous strata passing downwards into sandstone. These strata have furnished me with remains of Fishes, one of which consists of a

head with a long muzzle, armed with formidable sharp sauroid teeth, and rows of smaller ones. This Sir P. Egerton considers to be allied to the *Sphyrænodus* of the London clay. Another ichthyolite, of much less considerable dimensions, possessed cycloid scales of a pattern hitherto unrecognized.

On the west side of Phizdura, which is only 3 miles E.S.E. of Mángali, there is a hill of trap somewhat like that at Dongargaum, but not so high. It also overlies a fossiliferous deposit, though not of yellow limestone as there, but of red clay exactly like that which is cultivated at the base of Gi*dad* Hill. The organic remains at Phizdura may be gathered in abundance from the surface of a field, and comprise bones of large Pachyderms, coprolites of various sizes, a Saurian tooth, the vertebra of a large Fish, and fragments of the plastron of a freshwater Tortoise. I have no doubt that the Pachydermatous bones will be found the same as those dug out from a bed under trap at Jabbalpur, the connexion of which with the intertrappean shell-stratum of that district has never yet been made out. Phizdura supplies the wanting link. There we have Pachyderms and Molluscs together in one and the same deposit. If, as it may be presumed, the Pachyderms of Phizdura are identical with those at Jabbalpur, then, there being no question that the shells of Phizdura are the same as those of the fossiliferous intertrappean deposit, it follows that the *bone-bed under trap* at Jabbalpur is contemporaneous with the *shell-bed between trap* there as in other localities of Central India.

To determine, then, the age of this deposit, sometimes subtrappean, sometimes intertrappean, becomes an important consideration. In a paper presented to the Bombay Br. Royal Asiatic Society in March 1853, I gave my reasons for believing that it was Eocene. I suppose this will now be conceded by all. The only subject of uncertainty is to what subdivision of the Eocene it belongs. The examination of our fossils has not been carried far enough to justify any very determinate opinion on this point, and it becomes me therefore to speak with hesitation.

The only Indian formation with which the rocks under discussion can be compared is the Nummulitic, so amply illustrated by D'Archiac. Not one of his fossils, however, seems to be specifically identical with ours, though there is a considerable resemblance in form between his *Natica Dolium*, *Turritella affinis*, and cast of a *Cerithium* on the one hand, and our *N. Stoddardi*, *T. prælonga*, and cast of *C. Stoddardi* on the other. Though there is little similarity in shape between his *Vicarya Verneuili* and our *V. fusiformis*, yet it shows at least an approximation in age between the Nummulitic and our Intertrappean to find that these are the only two formations as yet known to imbed species of this genus. But perhaps the fossil that bears most closely on the matter in hand is the *Physa nummulitica*. D'Archiac does not seem to be quite sure whether the fossil is a *Physa*; but I think there can be little question that his figures represent specimens of that genus. His *Physa* may not be fully grown, in which case it may be specifically identical with

P. Prinsepii, the young specimens of which at Tákli are of the same size as well as form. But if it be an adult, then it is obviously of a different species; and, as it approaches nearer to the modern dimensions of the genus, I should be inclined to hold, that our intertrappean deposit with its huge Physas falls under a division of Eocene lower than the Nummulitic strata, in which it occurs.

This latter conclusion would appear to be borne out when we apply the per-centage rule to the solution of the problem. I have shown my freshwater fossil shells to Mr. Benson, the highest authority on the molluscs of our Indian lakes, and he gives it as his opinion that not one of the specimens submitted to him exactly corresponds to anything he has seen. I have had access to Mr. Cuming's splendid series of marine shells, as well as to our National Collection, and I have not been able to detect among the fossils from Rájámandri one existing species either from India or anywhere else.

On the essential differences between the Rájámandri shells and those now inhabiting Eastern seas, it does not become me to speak, as I have little personal acquaintance with our Indian coast; but my residence in the interior of the country afforded me opportunities of observing the lacustrine molluscs of Central India, and I could not help being struck with the marked distinction between the ancient Testacea and those still existing there. The present *Melaniæ* are much larger and stouter than their fossil congeners, and so generally are our living *Paludinæ* and *Limnææ*. And more than this: *Physa* and *Valvata*, two genera of our rocks, have disappeared from the Deccan, while *Ampullaria* and *Planorbis*, that have come in their places, are not to be found in our strata. A change equally great has occurred in the fishes, and one perhaps still more decided in the Flora; but on these I must not dwell, for I feel that this paper has already extended to too great a length.

And now I would desire to indicate, in as few words as possible, the rocks to which I consider ours nearest in age. If the "Nummulitic" *Physa* of Northern India be too small to agree with the *P. Prinsepii* of Nágpur, there is one on the continent of Europe which is well nigh large enough—I mean the *P. gigantea* of Rilly la Montagne. At this Lower Eocene locality we find other shells, that may be allied to our slender *Limnææ*—I allude to those regarded by De Boissy as *Achatinæ*. Again, coming to British strata of Lower Eocene age, I would point out the similarity of our larger fish from Dongargaum, our *Lepidosteus*? scales, and our *Pseudoliva*, to remains found in the London clay. Finally, some of our fruits bear a considerable resemblance to those discovered in the Isle of Sheppey and contemporaneous deposits in Belgium*.

From all these facts I am disposed to deduce the inference that our

* While this paper is passing through the press, I have seen the vegetable remains recently found in the clays of the Woolwich series in the neighbourhood of Dulwich. They comprise specimens of those peculiar strobiliform fruits so abundant at Nágpur and in Sheppey, which, beginning in the chalk as *Carpolithes Smithiæ*, seem to have attained their greatest development in the Lower Eocene. (April 2, 1860.)

intertrappean or subtrappean deposit belongs to the Lower Eocene, as I pointed out in papers read before the Bombay Br. R. As. Society in 1853, and the Geological Society in 1854.

The part of the sea in which the intertrappean deposit at Rájámandri was formed was evidently shallow, and connected with the great sheet or sheets of fresh water of the same age; for all its shells are such as are found at no great depth, many are comminuted as if they had been washed against the shore, and they are intermingled with *Physa Prinsepii*, *Paludina normalis*, *Chara Malcolmsonii*, and *Chara elliptica**, which must have been brought down from a lake. From the absence of Corals and Cirripeds, and the occurrence of such shells as *Psammobia*, *Tellina*, &c., it would appear that the shore of this sea was not bold or rocky, but a flat sandy or rather muddy beach.

The climate of India, at the period when this deposit was formed, seems to have been hot, as ably pointed out by Mr. Murray in the conclusion of his paper on the fossil insects (p. 185); but, adverting to the abundance of the genera *Physa* and *Valvata*, I think not so hot as the Deccan is at present.

The Pachydermatous remains from India are not all of one era. Some of the Narbaddá bones are from a subtrappean bed, as are those at Phizdura, but others are obtained from the river-basin. Those from the Siwálik Hills seem to occupy a stratigraphical position intermediate between these two, being combined with shells, some of which (unlike those from under the trap) agree with existing species, though there is not so great a proportion of these as in the fossiliferous deposit of our river-basins. The remains from the subtrappean strata of Jabbalpur and Phizdura are most likely Lower Eocene; those from the sub-Himalayas, as has been shown by others, are Upper Miocene; while those from the banks of the Narbaddá and similar situations cannot be more ancient than an upper subdivision of the Pliocene.

The upper sandstone of Nágpur, or, to use a term recently introduced by Dr. Oldham to supersede the loose designation of "diamond-sandstone," the Mahadewa sandstone of India, like the subtrappean deposit, which it underlies, is most probably of Lower Eocene age, and plutonic rocks have risen to the surface, and metamorphic rocks been formed since its deposition.

There appears to have been but one great outpouring of basalt in Central India, which has become vesicular below the Physa-bed, and nodular above it.

NOTE.—Geographical position of the localities mentioned in the preceding and following papers:—

I. In the province of Nágpur.

Tákli, 2½ miles N.W. of Nágpur city.
Telankhe*d*i, 3 miles W. of Nágpur city.
Pahá*d*singha, 40 miles W.N.W. of Nágpur city.
Little Tisti, 45 miles N.W. of Nágpur city.

* This is a new species of *Chara*, intended to be described on a future occasion.

Godni Bhokárá, 6 miles N. of Nágpur city.
Butára near Machhagho*d*a, 100 miles N. of Nágpur city.
Mahadewa Hills, 120 miles N.N.W. of Nágpur city.
Gi*d*a*d* Hill, 40 miles S. of Nágpur city.
Chikni, 60 miles S. of Nágpur city.
Karwa*d*, 3 miles W. of Chikni.
Mángali, 6 miles N.E. of Chikni.
Phizdura, 8 miles E. of Chikni.
Ko*d*bárá, 11 miles E. of Chikni.
Dongargaum, 16 miles E.S.E. of Chikni.

II. Beyond the province of Nágpur.

Síp Ghat north of Ellichpur, 120 miles W.N.W. of Nágpur city.
Chichundra, 80 miles N.W. of Nágpur city.
Jabbalpur, 170 miles N.E. of Nágpur city.
Kárúni, 100 miles S.S.W. of Nágpur city.
Mekalgandi Ghát, 150 miles S.S.W. of Nágpur city.
Rájámandri, 350 miles S.E. of Nágpur city.
Káteru, 2 miles N. of Rájámandri.
Panga*d*i, 10 miles W. of Rájámandri.

Description of Fossil Shells, *from the above-described Deposits.* By the Rev. S. Hislop.

I. Shells from the Freshwater Strata of Nágpur and neighbouring parts of Central India.

Melania quadrilineata, J. Sowerby, Trans. Geol. Soc. Lond. 2 ser. vol. v. pl. 47. figs. 17–19.

This species was discovered by Dr. Malcolmson, who gives Chikni as the locality where it is met with in the province of Nágpur. That and the neighbouring village of Karwa*d* have furnished the majority of my specimens, though a few have been obtained from Pahá*d*singha, where they are found along with the species next mentioned. Beyond our frontier, *M. quadrilineata* is common at Káruni, intermingled with Unios.

Melania Hunteri, sp. nov. Pl. V. fig. 1.

M. testa subulata; anfractibus 7–8, lævibus, convexis; sutura profunda; apertura oblique ovata. Long. ·5; lat. ·2 unc.

The present species differs from the preceding in being destitute of *carinæ*, in place of which it is furnished with a slight longitudinal striation. Abundant at Pahá*d*singha. The specific name is given in honour of the Rev. Robert Hunter, my esteemed colleague for many years in the work of evangelization, as well as my highly accomplished associate in geological research.

Paludina normalis, sp. nov. Pl. V. figs. 2 *a*, 2 *b*.

P. testa rimata, ovato-conica; apice subacuto, sed sæpius truncato; anfractibus 5–6, ventricosis, sutura profunda separatis; apertura rotunda; peristomate continuo. Long. ·8; lat. ·5 unc.

At Karwa*d* rare; at Tákli and Phizdura more abundant. Specimens have also been procured from Ambiákanti and Tándrá, near Olam in Hyderabad.

Those found at Tákli are generally small, and truncate at the apex, leaving only about $2\frac{1}{2}$ whorls remaining. Those at the other localities

are larger and complete. It is interesting to note that one specimen has been discovered in the estuarine beds at Káteru, decollate like the generality of those furnished by the freshwater strata at Tákli. This is the only species which in size and shape resembles the typical forms of *Paludina*, as represented by *P. vivipara* of Britain and *P. Bengalensis* of India.

PALUDINA DECCANENSIS, J. Sowerby, Trans. Geol. Soc. 2 ser. vol. v. pl. 47. figs. 20, 22.

Besides the localities in the Hyderabad State, where this species was met with by Malcolmson, it was also found by him in our province at Chikni. Our observations have ascertained it to be common wherever the strata are fossiliferous; but the best specimens are to be had at Tákli, Karwa*d*, and Chikni. My largest measures ·3 by ·2 of an inch. One of the specimens figured by Sowerby (fig. 21) somewhat exceeds these dimensions; but I am inclined to think that the one represented there, as well as in fig. 23, belonged rather to the genus *Valvata*. A *Paludina*, apparently of the present species, was found in the sandstone underlying the lower trap of Sitábaldi Hill.

PALUDINA WAPSHAREI, sp. nov. Pl. V. fig. 3.

P. testa parva, ovato-conica, lævi, apice acuto, spiraliter unifasciata, rarius bizonata; anfractibus 5, convexis; sutura impressa; apertura ovata, superne angulata. Long. ·2; lat. ·1 unc.

At Karwa*d* somewhat frequent; at Phizdura rare. This elegant little shell I have great pleasure in dedicating to my friend Major Wapshare, of the Madras Army, who prosecuted the study of Indian geology with much zeal, and added to our collection of Nágpur fossils many important contributions. It bears a considerable resemblance to *P. Deccanensis*, but differs from it in its smaller size, in the thinness of its shell, and in the possession of stripes of colour. In the common specimens there are two bands, one of which is always covered up by the succeeding whorl, the other being left visible a little below the middle of the whorl. But specimens occur in which, besides the hidden stripe, there are two bands adorning the exposed portion of the volutions, which they divide into three equal parts.

PALUDINA ACICULARIS, sp. nov. Pl. V. fig. 4.

P. testa elongato-turrita, subulata vel subcylindracea, lævi, unifasciata; anfractibus 8–10, subconvexis; apertura oblique ovata, superne angulata. Long. ·33; lat. ·08 unc.

At Telankhe*d*i very abundant; less frequent at Butárá. It occurs also at Chichundra, beyond the boundary of our province. At Tákli and Little Tisti, shells of the same slender form are met with, but exhibiting no band of colour, most probably on account of the unfavourable character of the matrix, or from having been bleached before they were imbedded.

PALUDINA PYRAMIS, sp. nov. Pl. V. fig. 5.

P. testa rimata, pyramidata; apice acuto; anfractibus 9, subconvexis, regulariter crescentibus; apertura ovata, superne angulata. Long. ·25; lat. ·1 unc.

Very rare. Found at Telankhe*d*i with the last-mentioned, but

only as a calcedonous cast, so that it cannot be determined whether the shell was striped, though analogy would lead to the belief that it was.

PALUDINA SUBCYLINDRACEA, sp. nov. Pl. V. fig. 6.

P. testa elongato-turrita, unifasciata; apice subacuto; anfractibus 8–10, convexiusculis; apertura parva, ovata, angusta, superne angulata; labii margine subreflexo. Long. ·45; lat. ·17 unc.

Telankhe*di*, rather rare. The dimensions of the largest specimen are given above. It has, however, lost at least two of its upper whorls; otherwise it would have exceeded half an inch in length.

PALUDINA SANKEYI, sp. nov. Pl. V. fig. 7.

P. testa subfusiformi, unifasciata; anfractibus 9, valde sive parum convexis; sutura impressa; apertura ovata, superne angulata. Long. ·4; lat. ·17 unc.

Telankhe*di*, somewhat common. With this interesting species I have associated the name of Captain Sankey, of the Madras Engineers, who investigated with much success the deposit in which it is found, and has since earned the highest honour at the hands of our Queen, by his distinguished valour in recent Indian campaigns.

The five species just described constitute a group requiring more special notice.

It may be supposed that the differences between *P. Deccanensis* and *P. Wapsharei* are not so great as to warrant their being made into two separate species. Variety in the colouring of a *Helix* or *Bulimus* I admit not to be a sufficient ground for specific distinction; but I am not aware that there is the same latitude in freshwater genera. In the genus *Paludina*, it is well known that, when a species is banded, there is no great agreement in the number of stripes; but in all the Indian species that have fallen under my observation, I have never found one wholly destitute of stripes that is usually possessed of them. This seems also to have been the rule in former days. Of the three species, *P. acicularis*, *P. subcylindracea*, and *P. Sankeyi*, I have discovered no well-preserved specimens unstriped, in the same matrix as yielded the striped specimens. Now, at Karwa*d*, in the very same fragment of rock, and equally well-preserved, we meet with two sorts of specimens,—one larger, thicker in the shell, and unstriped; the other smaller, thinner, and sometimes exhibiting one band of colour, sometimes two. To me it appears there is as much difference between these two forms as between many others that are properly reckoned specifically distinct.

The difficulty about the remaining forms, which I have grouped with *P. Wapsharei*, relates to a still higher question—that of genus. At first sight the slenderness of these four species, taken along with the more or less reflexed character of their inner lip, would lead to the conclusion that they belong to *Bulimus*; and with this inference would agree the position of the coloured stripes which three of them exhibit, and which it is presumed all possessed. For some time I entertained this view; and I find that it has commended itself to most of my friends in this country, who have examined the specimens. But the abundance in which they have been procured at Telankhe*di*, almost to the exclusion of other shells, forbids our

assigning them to any genus of land molluscs. In this perplexity, the discovery of *P. Wapsharei* was most opportune. In it we have a shell that so nearly agrees with *P. Deccanensis* in form as to admit of no doubt being entertained that they are both of the same genus; while it also agrees so exactly with the four species under consideration, in regard to the position of the stripes of colour, as to warrant our using the certainty of our knowledge as to *its* genus, in the determination of the genus of those that are more doubtful.

If this be allowed, then the group of *Paludinidæ* which I have indicated bears an obvious relation to the species described by Olivier under the name of *P. bulimoides,* which is characterized by coloured bands situated precisely as in our five *fossil* species of *Paludina,* and varying in number from one to two in the exposed portion of each whorl, after the manner of *P. Wapsharei.* Perhaps an examination of the animal of *P. bulimoides,* which inhabits Syria and Egypt, may afford some grounds (as suggested to me by that distinguished naturalist, Mr. S. P. Woodward) for constituting it and the fossil species resembling it into a subgenus.

PALUDINA TAKLIENSIS, sp. nov. Pl. V. figs. 8 *a*, 8 *b*.

P. testa ovato-conica, elongata, lævigata, apice truncato; anfractibus 7–8, convexis, valde separatis; apertura ovata. Long. ·5; lat. ·2 unc.

Found at Tákli, from which locality it derives its specific name. The dimensions above given are of a smaller specimen. The only other one that has been discovered consists of three lower whorls, indicating a shell, when entire, of at least ·7 by ·28 of an inch.

PALUDINA SOLUTA, sp. nov. Pl. V. fig. 9.

P. testa crassa, ovato-conica; apice obtuso; anfractibus 5, ventricosis; sutura incisa; apertura subrotundata. Long. ·5; lat. ·3 unc.

At Karwa*d*, rare; but common in the Narbaddá territory, whence specimens are brought to Nágpur by stone-polishers as paper-weights. This species agrees with the preceding one in the looseness of its whorls, but differs from it in its greater breadth and the smaller number of its volutions.

PALUDINA CONOIDEA, sp. nov. Pl. V. fig. 10.

P. testa conoidea, apice subacuto; anfractibus 6, complanatis; apertura ovata. Long. ·41; lat. ·25 unc.

Found occasionally in the red clay of Phizdura.

PALUDINA RAWESI, sp. nov. Pl. V. fig. 11.

P. testa magna, elongato-turrita, plerumque truncata; anfractibus 8, forsitan usque ad 11, convexis; sutura impressa; apertura ovata, superne angulata; peristomate interrupto; labii margine reflexo, subcrassato. Long. ·65; lat. ·3.

Tákli, common. The measurement given is of a specimen that has lost only its two uppermost whorls; but a much larger specimen, that is so decollate as to have only 4½ whorls left, measures ·9 by ·5 of an inch, and must have extended to an entire length of 1½ inch. Some specimens exhibit a tendency to a pupiform appearance. This species, which possesses some similarity to the existing *P. contorta* of Shuttleworth, I have named in honour of W. W. Rawes, Esq., of the Madras Medical Service, whose love for natural history is

equalled only by the generosity with which he bestows on others the valuable specimens, both recent and fossil, that he has discovered.

PALUDINA VIRAPAI, sp. nov. Pl. V. fig. 12.

P. testa turrita; apice acuto, plerumque truncato; anfractibus 8, forsitan ad 10, complanatis; sutura sat impressa; apertura ovata; peristomate interrupto; labii margine reflexo. Long. 1·1?; lat. ·5 unc.

Tákli, with the last,—the chief difference between the two being, that in young specimens as well as old of *P. Rawesi* the base is rounded, whereas in *P. Virapai*, as might be expected from the flatness of the whorls, it is angular. In affixing the specific name I wish to acknowledge the services of Virapa, my collector, a native remarkable for intelligence and acuteness of observation.

VALVATA MINIMA, sp. nov. Pl. V. fig. 13.

V. testa perpusilla, discoidea, subtus late umbilicata; anfractibus 3, rotundis, verticaliter tenuissime striatis; apertura rotunda. Diam. ·05 unc.

At Little Tisti, Karwad, Butárá, and Káruni, somewhat frequent. At the two localities first mentioned, the specimens retain the delicate shell, with its very fine striation. This is the most diminutive species of *Valvata* that I have seen. It is considerably smaller than the young of *V. cristata*, which has received the specific name of *V. minuta*. The figure is magnified.

VALVATA UNICARINIFERA, sp. nov. Pl. V. fig. 14.

V. testa turbinato-conoidea; apice subacuto; anfractibus 5–6, subventricosis, infra suturam unicarinatis; umbilico magno; apertura subrotunda. Long. ·4; lat. ·27–·38 unc.

This shell is considerably more elevated in the spire than any recognized species of *Valvata* with which I am acquainted; still the resemblance which its *carina* bears to those of *V. tricarinata* of Say, and its funnel-shaped umbilicus, remove from my mind all hesitation in referring it to that genus. The American species displays two *carinæ* on the exposed part of the whorl; whereas our fossil species has only one, which occupies the position of the upper *carina* in *V. tricarinata*. I believe it has a *carina* in the part of the whorl that is covered up, as is the case with the other; but cannot speak definitely, owing to the difficulty of detaching the shell entire from the siliceous matrix in which it is found in both of its localities, Butárá and Málanwádá. At the former place it occurs along with *V. minima*.

VALVATA MULTICARINATA, sp. nov. Pl. V. figs. 15 *a*, 15 *b*.

V. testa turbinato-conoidea, multicarinata; apice subacuto; anfractibus 6, ventricosis, inter carinas verticaliter ornate striatis; umbilico magno; apertura subrotunda. Long. ·4; lat. ·3 unc.

Common at Little Tisti; rare, and only as a cast near Tákli. This shell is very difficult of determination. Some have considered it a *Cyclostoma*; others have preferred the allied genus *Leptopoma*; but, in my opinion, it occurs too frequently, and that over a large area, to belong to any family of land shells. Its sculpture, consisting of numerous spiral keels or ribs with intermediate vertical striation, is very k e the ornamentation of *Paludina costata* of Quoy; but, at the same

time, it is characterized by such a decided perforation, as to demonstrate that it has no affinity with either that or any other species of *Paludina*. Judging from its form, which so greatly resembles that of the species last described, I am inclined to place it in the same genus. And it is interesting to discover that, though the American existing species of *Valvata* already referred to, and the fossil *V. multiformis*, are the only ones which are known to possess as many as three obvious *carinæ*, yet there is a tendency to this structure even in the common species *V. piscinalis*, which, under a lens, exhibits several rudimentary *carinæ*. Our fossil would be ranked with the *V. striata* of Philippi, which it much resembles, were it not that the position of the Sicilian shell itself is doubtful, it being supposed to be very improbable that a freshwater mollusc should be found entombed with marine organisms; but perhaps the occurrence of a single specimen of *Paludina normalis* in similar circumstances, at Káteru, may go far to obviate this objection. If we look to lacustrine deposits for analogues, I would point to the Grignon beds, where we meet with a univalve which, under the specific name of *cornu-pastoris*, Lamarck has classed with the genus *Cyclostoma*. But as this shell is extremely like the Indian one now under consideration, and as the latter cannot, as I have remarked, belong to a terrestrial genus, I would take the liberty of referring them both to the only lacustrine genus which seems at all likely—I mean *Valvata*. And it is not a little remarkable that at Grignon, where *C. cornu-pastoris* occurs, there is also found *C. spiruloides* of Lamarck, which Deshayes does not consider to be a *Cyclostoma*, but which, as it appears to me, is obviously another species of *Valvata*; and thus it would seem that we have an association of forms at a locality in France, which finds its counterpart in the combination of *V. multicarinata* and *V. minima* at Little Tisti in Central India.

VALVATA DECOLLATA, sp. nov. Pl. V. figs. 16 *a*, 16 *b*.

V. testa ovato-conica, paululum elongata, tenuiter multicarinata; apice truncato; anfractibus fortasse 9, convexis, inter carinas verticaliter elegantissimo striatis; apertura ovata. Long. ·45 ?; lat. ·28 unc.

At Tákli, rather rare. This species agrees with *V. unicarinifera* and *V. multicarinata* in the size of its umbilicus, and with the latter in great measure in the character and number of its *carinæ*, but it differs from both in the elongation of its form. All the specimens, both old and young, that I have seen are truncate. This species evidently departs more widely than any other from the typical form of *Valvata*.

SUCCINEA NAGPURENSIS, sp. nov. Pl. V. fig. 17.

S. testa parvula, ovato-oblonga; spira mediocriter exserta; apice obtusiusculo; anfractibus 4, convexis, obliquis, ultimo spiram multo superante; apertura ovata. Long ·27; lat. ·16 unc.

Very rare, only one specimen, and that a calcedony cast, having been discovered at Telankhe*d*i, along with the slender, striped Paludinas.

LIMNÆA OVIFORMIS, sp. nov. Pl. V. figs. 18 *a*, 18 *b*.

L. testa ovato-ventricosa, apice acuto; anfractibus 5–6, convexis, ultimo spira longiore; apertura late ovata, superne angulata. Long. ·5–·72; lat. ·25–·4 unc.

Very rare at Tákli and Phizdura, from the former of which places the smallest specimen was obtained. Phizdura yielded two, both of them larger than that from Tákli. The general contour of this species is somewhat typical, possessing an intermediate character between *L. inflata* and *L. ovum*. Of existing Indian species, *L. luteola* approaches very near it, both in size and shape.

LIMNÆA SUBULATA, J. Sowerby, Trans. Geol. Soc. 2 ser. vol. v. pl. 47. fig. 13. Pl. V. fig. 19.

L. testa subfusiformi, apice acuto; anfractibus 6½, convexis, sutura impressa separatis, ultimo spira breviore; apertura angusta; labio brevi, sinuato; labro arcuato. Long. 1·1; lat. ·25 unc.

Telankhe*d*i, somewhat common. As Sowerby's description and figure were from an imperfect specimen, I have here given a new description, and another figure is appended in Pl. V. fig. 19.

LIMNÆA ATTENUATA, sp. nov. Pl. V. fig. 20.

L. testa elongato-turrita; spira attenuata; apice acuto; anfractibus 7–8, convexiusculis, sutura excavata separatis, ultimo longitudinis trientem vix superante; apertura parva, acute ovata; labio brevissimo; labro arcuato. Long. 1·05; lat. ·2 unc.

Telankhe*d*i, rather rare. I am not sure that this form is specifically distinct from the preceding, along with which it is found. The chief points of difference between the two are, that the one which I have ventured to distinguish as *attenuata* is considerably more slender, and at the same time exhibits more whorls than the other in an equal length of spire. The great resemblance between this form and the living North American species *L. gracilis* scarcely needs to be pointed out. In India there is nothing at all similar to it in the genus *Limnæa*, though there is in the allied sinistral genus, *Camptoceras*, established by Benson.

LIMNÆA TELANKHEDIENSIS, sp. nov.

Var. *peracuminata*. Pl. V. fig. 21 *a*.

L. testa elongato-turrita, apice acuto; anfractibus 8, planulatis, superne ventricosis, sutura profunda separatis, ultimo longitudinis dimidio longiore; apertura angusta, ovata, superne angulata; labio brevi; labro subarcuato. Long. ·65; lat. ·16 unc.

Telankhe*d*i, common.

Var. *Radiolus*. Pl. V. fig. 21 *b*.

L. testa obeso-fusiformi, apice obtuso; anfractibus 7, convexiusculis, ultimo longitudinis dimidio breviore; sutura satis impressa; apertura oblongo-ovata, superne coarctata. Long. ·5; lat. ·15 unc.

Telankhe*d*i, Tákli, Butara, and Karwa*d*, somewhat frequent.

LIMNÆA SPINA, sp. nov. Pl. V. fig. 22.

L. testa subcylindracea vel turrito-aciculari, apice acuto; anfractibus 7–8, convexiusculis, ultimo longitudinis trienti fere æquali; apertura parva, angusta, ovata, superne coarctata. Long. ·4; lat. ·1 unc.

Telankhe*d*i, and Tákli frequent.

In closing my observations on the genus *Limnæa*, I cannot avoid calling attention to the unusual form which, for the most part, it assumed in India at the period of our intertrappean formation. Of several hundred specimens which I have discovered, only three have been found of the inflated type so common at the present day. All the others have belonged to species remarkable for the number and slenderness of their volutions. It may be supposed that, with such a form, they ought to be referred to some other genus (e.g., *Achatina* or *Glandina*, and *Cæcilianella*); and certainly our *L. spina* and *L. Telankhediensis* in both its varieties remind us of such a group of *Achatinæ* as is represented by *A. balanus*, *A. subulata*, and *A. solidula*, or of *Cæcilianella* as comprehends *C. Grateloupi*, *C. nyctelia*, and *C. nanodea*; but I do not see, if the larger species of these slender shells are to be classed with the *L. gracilis* of Say, how the smaller can be separated. They have the same form of spire and aperture, and the same kind of striation, whereas the groups of land shells above alluded to are distinguished by the general smoothness or, even, polish of their surface. But the argument which weighs most with me, is that it is not conceivable that the remains of any terrestrial genus of mollusc should be found so abundantly and widely in our deposit as these shells are.

It is not easy to point out strata where a similar series of fossils may be met with. In a paper on the Geology of Rilly la Montagne*, which was brought to my notice by my friend Dr. Oldham, De Boissy describes several species of univalves under the generic name of *Achatina*. Our *L. attenuata* strikingly resembles his *A. Rillyensis* when the latter is a right-handed shell; and others of our species have an affinity to others of his in the same condition; but none of ours have any tendency to a sinistral direction of the spire. Whether, with this important difference, the fossils from the two localities belong to the same genus, it is not for me to offer an opinion.

PHYSA PRINSEPII, J. Sowerby, Trans. Geol. Soc. vol. v. pl. 47. figs. 14–16.

This species was established by Sowerby from specimens found by Malcolmson, at Chikni in the province of Nágpur, and one or two localities in the Hyderabad territories. As they do not seem to have been either numerous or in good condition, I shall take the liberty of submitting another description from the ampler materials at my command. All may be arranged under three forms,—the first of which I would regard as the type of the species, and the other two as varieties on the opposite extremes.

PHYSA PRINSEPII (*normalis*). Pl. V. fig. 23 *a*.

P. testa ingente, ovata, eleganter striata, spira sat longa; anfractibus 7–8, convexis, sutura impressa separatis, ultimo spira plene duplo majore; apertura ovato-oblonga, superne angulata; columella incrassata. Long. 2·75; lat. 1·56 unc.

* Mém. Soc. Géol. France, 2 sér. vol. iii.

Var. *elongata*. Pl. V. figs. 23 *b*, 23 *c*.

P. testa subturrito-elongata, spira producta, apice acutiusculo; anfractibus 7–8, convexis, sutura distincta separatis, ultimo longitudinis dimidio fere æquali; apertura ovato-oblonga, superne angulata; columella incrassata. Long. 2·67; lat. 1·2 unc.

Var. *inflata*. Pl. V. fig. 23 *d*.

P. testa ovato-ventricosa, maxime contorta, spira brevissima, apice obtuso; anfractibus 7–8, turgidis, sutura impressa separatis, ultimo spira fere triplo majore; apertura ovato-oblonga, superne angulata; columella incrassata. Long. 2·8; lat. 1·85 unc.

All these forms may be procured, within the province of Nágpur, wherever the deposit is fossiliferous, especially at Tákli, Telankhe*d*i, Butárá, and Phizdura. Excellent specimens have been obtained also from Chichundra by Captain Sankey and others; but the best have been kindly forwarded to me from the hills on the north of Ellichpur, by Dr. Bradley, of the Bombay Medical Service. Michelin has named the species that occurs at Rilly *P. gigantea*, from its great size; but his largest specimen falls $\frac{3}{10}$ths of an inch short of one of ours in length. But these dimensions are insignificant to those of a specimen that I have seen from Ságar, which measured 3·8 inches in length, and, making allowance for crushing, 2·4 in breadth. Most of our specimens, however, are young, and in this state do not much exceed in size *P. nummulitica* from the marls of Sabáthu, which they also not a little resemble in shape. The occurrence of the last-mentioned species in marine strata is paralleled by the discovery of *P. Prinsepii* at Panga*d*i and Káteru.

Unio Malcolmsoni, Hislop.

Unio tumida, J. Sowerby, Trans. Geol. Soc. 2 ser. vol. v. pl. 47. figs. 11 & 12.

U. testa lævi, suborbiculari, inflata, subæquilaterali; valvulis subcrassis; margine ventrali intus aliquando crenato. Diam. ·65; long. ·7; lat. ·8 unc.

This shell was first found by Malcolmson at Mekalgandi Ghát, which is the only locality that has furnished my specimens. For Sowerby's specific name *tumida*, which in its masculine form had already been employed by Retzius to designate an existing species, I have taken the liberty of substituting the name of the lamented discoverer. The length of this and other bivalves here described is measured from the umbo to the base; the breadth from the anterior to the posterior margin.

Unio Deccanensis, J. Sowerby, Trans. Geol. Soc. 2 ser. vol. v. pl. 47. figs. 4–10. Pl. VI. figs. 24 *a*, 24 *b*, 24 *c*.

U. testa lævi, subelliptica, obliqua, valde inæquilaterali; postice producta, truncata et compressa; valvulis crassis, obscure radiatis; margine ventrali intus sæpius crenato; natibus prominulis, subterminalibus, ad apices elegantissime radiato-rugosis; dente cardinali parvo, laterali prælongo atque subarcuato. Diam. 1·7; long. 2·2; lat. 3·4 unc.

Síp Ghát, north of Ellichpur and Káruni, common. We have thought it requisite to furnish a more complete description; and a new figure is given in Pl. VI. figs. 24 *a*, 24 *b*, 24 *c*.

Unio Hunteri, sp. nov. Pl. VI. fig. 25.

U. testa lævi, subquadrangulari, inæquilaterali, postice compressa; valvulis sub-

crassis, obscure radiatis; margine ventrali intus crenato; natibus prominulis, ad apices ornatissime radiato-rugosis. Diam. 1; long. 1·5; lat. 2·4 unc.

Káruni, common. Dedicated to the Rev. R. Hunter. This shell very much resembles the last. The valves of both have an inward radiated structure, which becomes quite apparent on their surface being weathered. But besides a difference in size between them, the anterior margin of *U. Deccanensis*, which is the larger species, is remarkable for its shortness, seeming as if it were entirely rounded off, while in *U. Hunteri* it is produced to an average length.

UNIO MAMILLATUS, sp. nov. Pl. VII. fig. 26.

U. testa subcuneiformi, inæquilaterali; postice producta, angulata, compressa; valvulis crassis et una mamillarum serie instructis; natibus elevatis, ad apices decore radiatis. Diam. 1·6; long. 2·3; lat. 3·9 unc.

Káruni, frequent. There is no species of *Unio* in India at present to be compared with that now under consideration. The young of *Unio parma* from Tenasserim, I observe, is furnished with tubercles, but in a double row; and the shell is moreover much more orbicular. The well-known *U. spinosus* is the species which seems to come nearest ours, especially in the position of its single row of appendages.

UNIO IMBRICATUS, sp. nov. Pl. VII. figs. 27 *a*, 27 *b*, 27 *c*.

U. testa suborbiculari, subæquilaterali, interdum postice valde angulata; valvulis squamarum, seu magis imbricum, serie una instructis; margine ventrali intus crenato; natibus elevatis. Long. 2·2; lat. 2·3 unc.

Frequent at Mekalgandi Ghát along with *U. Malcolmsoni*. This shell is formed on the same model as the preceding in regard to the situation of the row of ornamentation, which is about the centre of the valve, and anterior to the umbonal ridge; but the shape of the valves and of the ornamentation in the two cases is very dissimilar.

UNIO CARTERI, sp. nov. Pl. VII. fig. 28.

U. testa lævi, transversa, subelliptica, compressa, inæquilaterali, ad basin emarginata; vavulis crassiusculis; natibus prominulis, ad apices elegantissime radiatis. Long. 1·7; lat. 3·5 unc.

Káruni, rather rare. This handsome shell, which, except in its being longer, exhibits a close affinity to *U. Jamesianus* of Lea, I propose naming after my friend H. J. Carter, Esq., of the Bombay Medical Service, who has done much towards the illustration of the geology of the East, as well as the elucidation of some of the obscurest points in animal and vegetable physiology.

In our series of fossil *Unionidæ*, which seems to be rather North American than Asiatic, there are some prevailing features. All, with the exception of *U. Malcolmsoni*, are characterized by an umbonal ridge more or less prominent, and, with the exception of it and *U. imbricatus* (both of which, from the nature of the matrix, possess a very indistinct surface), are ornamented with beautiful small curved furrows radiating from the apex of the umbo, and presenting their concave side towards its anterior margin. This kind of sculpture is somewhat like that which is seen on Unios in the Deccan at the present day; but it never covers so much of the beak, nor does one of the curved rays ever unite with another so as to form the undula-

tions so common on modern Indian Unios. It is worthy of notice that none of the beaks of our fossil bivalves had been eroded before being imbedded in the deposit,—a circumstance which would indicate a comparatively small quantity of acid in the waters of our ancient lake. Another peculiarity may be here mentioned; and that is the scarcity of the genus now engaging our attention in the Tertiary rocks of Nágpur. Excepting at Chikni, and at Karwa*d* and Ko*d*bárá, which are in its immediate neighbourhood, no Unios have been found at any of the numerous fossiliferous localities within our province, while they abound on the north, west, and south—in the Narbadda territory, in the ceded districts of Berar, and in the Hyderabad dominions. At Ko*d*bárá, where true Unios are met with, there are found nodular concretions, which have been crushed into a shape so very similar to that of *Unio* as to deceive all but a practised eye.

II. Shells from the estuarine strata near Rájámandri.

Fusus pygmæus, sp. nov. Pl. VIII. fig. 29.

F. testa minima, ovato-fusiformi, longitudinaliter costata, spiraliter striata; spira producta; anfractibus 6, superne subangulatis; apertura oblongo-ovata. Long. ·15; lat. ·08 unc.

Káteru, rare, only one specimen having been found. The figure is magnified.

Pseudoliva elegans, sp. nov. Pl. VIII. figs. 30 *a*, 30 *b*.

P. testa ovato-ventricosa vel ovato-globulosa, costata; spira brevi vel brevissima; anfractibus 5–6, ultimo ad basin unisulcato, super et subter sulcum striis ornato; apertura ovata, angusta vel lata; columella arcuata, callosa; labro simplici, superne incrassato. Long. 1·4; lat. ·9 unc.

Káteru, common. The extremes of form in this handsome shell are so great as to lead to the supposition that they belong to different species; but this idea vanishes on an examination of the intermediate forms. The congeners of the present species are to be sought under various names,—*e. g.* the *Sulco-buccinum fissuratum* of d'Orbigny, and the *Monoceros vetustus* of Conrad.

Natica Stoddardi, sp. nov. Pl. VIII. fig. 31.

N. testa ovata, inflata; spira brevi, apice subacuto; anfractibus 7, convexis, sutura vix impressa separatis, ultimo multo majore; apertura obliqua, semilunari, ad basin rotundata; columella arcuata, callosa; labro simplici, crasso; umbilico angusto. Long. 1·4; lat. 1·1 unc.

Káteru, common. Of this shell also there are several varieties, but all referable to one species. It possesses a spire longer than usual among Naticas, in this respect slightly surpassing *N. Dolium* (d'Arch.) of the Indian nummulitic rocks, which in other points of view it greatly resembles. In general contour it is also closely related to *N. intermedia* (Desh.), though smaller. I gladly dedicate this species to my obliging friend Capt. Stoddard, of the Public Works Department of Madras, in grateful acknowledgment of the valuable collection of estuarine fossils with which he has favoured me.

Cerithium multiforme, sp. nov. Pl. VIII. figs. 32 *a*, 32 *b*, 32 *c*.

C. testa subcylindracea seu elongato-pyramidali, seu etiam pupiformi; anfractibus 11–13, longitudinaliter costulatis; costellis 4–6, striis spiralibus granulatis;

ultimi anfractus basi subplana, spiraliter sulcata; apertura ovata; columella brevi; labro tenui, sinuoso.

Long.	·82	lat.	·16 unc.
„	·8	„	·27 „
„	1·05	„	·3 „

Káteru, common. Of all the protean shells from this deposit, the present is the most variable. The dimensions given above will convey an idea of the proportions of three of the most marked varieties.

CERITHIUM SUBCYLINDRACEUM, sp. nov. Pl. VIII. figs. 33 *a*–33 *d*.

C. testa multispirata, subcylindracea, acuminata; anfractibus planis, serie granulorum triplici cinctis; cingulo primo lato, reliquis angustis, æqualibus; ultimi anfractus basi plana, spiraliter sulcata; apertura subquadrata; columella brevissima, uniplicata. Long. 1·5; lat. ·23 unc.

Var. *a*, cingulis 4, moniliformibus; primo lato, secundo angustissimo, reliquis regulariter crescentibus.

Káteru, common; but the var. *a*. is not so abundant as the other.

CERITHIUM LEITHI, sp. nov. Pl. VIII. fig. 34.

C. testa elongato-conica; anfractibus subplanis, longitudinaliter costatis, spiraliter striis sulciformibus exaratis, ultimi anfractus basi tenuiter cancellata; apertura ignota. Long. 1·1; lat. ·45 unc.

Káteru, extremely rare. With this shell, of which only one specimen has fallen under my observation, I would connect the name of my friend A. H. Leith, Esq., of the Bombay Medical Service, one of the most accomplished naturalists in the East.

CERITHIUM STODDARDI, sp. nov. Pl. VIII. fig. 35.

C. testa elongato-conica; anfractibus 14–15, profunde confertimque spiraliter striatis, et costis ornatis; costis magnis, nodiformibus, medio acuminatis; apertura ovato-rotunda, canali latiusculo terminata. Long. 3·3; lat. 1·4 unc.

Káteru, common. This shell, which is perhaps the most marked of the series, possesses a character somewhat intermediate between the fossil *C. semicostatum*, Desh. and the existing *C. nodulosum*, Brug. Named after Capt. Stoddard.

VICARYA FUSIFORMIS, sp. nov. Pl. VIII. figs. 36 *a*–36 *c*.

N. testa fusiformi; anfractibus 10–12, planis, sutura lineari separatis, primis cingulis ornatis, ultimis lævibus; apertura parva, subquadrata, canaliculata; columella retroflexa; labro sinu insigni inciso. Long. 1·15; lat. ·4 unc.

Káteru, common, though specimens showing the perfect aperture are rare. This genus (which was established by d'Archiac for a shell from the Indian Nummulitic strata) is characterized by a deep notch in the outer lip. It is interesting to find a second species also in India. This is much smaller than the first, and is comparatively devoid of ornamentation, the little there is being confined to the upper whorls.

TURRITELLA PRÆLONGA, sp. nov. Pl. VIII. figs. 37 *a*–37 *d*.

T. testa turritissima, gracili; anfractibus numerosis, planis, superne cingulum latum granulosum, inferne sulcum unistriatum exhibentibus; spatio intermedio striis 5 subgranulosis ornato; ultimi anfractus striis spiralibus pene obsoletis; apertura ovato-rotunda. Long. 4·6; lat. ·5 unc.

Var. *a*, cingulo lato eminentiore, striis fortioribus, sulco obsoleto.

Káteru, common; var. *a*. somewhat rare.

HYDROBIA ELLIOTI, sp. nov. Pl. VIII. fig. 38.

H. testa parva, ovato-conica, lævigata, apice acuto; anfractibus 6, convexiusculis; sutura impressa; apertura ovata; labro simplici. Long. ·14; lat. ·07 unc.

Káteru, somewhat frequent. Named after the Honourable Walter Elliot, member of the Madras Council, who has given an account of the strata at Káteru, and is well known for his many scientific attainments. The figure is magnified.

HYDROBIA CARTERI, sp. nov. Pl. VIII. fig. 39.

H. testa minima, ovato-conica, lævigata, apice subacuto; anfractibus 5, convexis; sutura impressa; apertura ovata; labro simplici. Long. ·09; lat. ·05 unc.

Káteru, common. This species is in every respect smaller than the preceding. It is named after H. J. Carter, Esq. The figure is magnified.

HYDROBIA BRADLEYI, sp. nov. Pl. VIII. fig. 40.

H. testa minima, turrita, apice subacuto; anfractibus 5(?), convexis; sutura impressa; apertura oblongo-ovata; labro simplici. Long. ·09; lat. ·035 unc.

Káteru, rare. Dedicated to W. H. Bradley, Esq., to whom, as mentioned above, I am indebted for my best specimens of *Physa*. The figure is magnified.

HEMITOMA? MULTIRADIATA, sp. nov. Pl. VIII. fig. 41.

H. testa elliptica, depresso-conica, decussata; apice subcentrali, costulis majoribus 18–20 ab apice radiantibus, minoribus 3 interjectis; costulis, præsertim ad anticum marginem, squamosis. Ax. maj. ·45; min. ·33; alt. ·2 unc.

Káteru, rare, only one specimen having been found: this has in front of the apex a fissure, which occasions some difficulty in determining the genus; but most probably it is only accidental. The figure is magnified.

OSTREA PANGADIENSIS, sp. nov. Pl. IX. fig. 42.

O. testa ovato-elongata, superne acuta; valva superiore plana, margine intus crenulato. Long. 2·9; lat. 1·95 unc.

Pangadi, very common. I regret that I have had an opportunity of examining only the upper valve.

ANOMIA KATERUENSIS, sp. nov.

Var. *suborbicularis.* Pl. IX. fig. 43 *a.*

A. testa suborbiculari, subæquilaterali; valva superiore convexa, solidiuscula, irregulariter radiata; umbone vix prominente. Long. ·75; lat. ·88 unc.

Var. *Modiola.* Pl. IX. fig. 43 *b.*

A. testa ovato-elongata; umbone prominente. Long. ·77; lat. ·55 unc.

Káteru, rare. Of the two varieties here described, I have not seen the lower valve.

LIMA, sp.

A small species of this genus is met with, though rarely, at Káteru; but my only specimen has been lost.

PERNA MELEAGRINOIDES, sp. nov. Pl. IX. fig. 44.

P. testa meleagriniformi, valde rostrata, compressa, obsolete concentrice laminata; margine cardinali plano, recto, 5–7ties sulcato et dentato. Long. 1·76; lat. 1·55 unc.

Káteru, rather rare.

MODIOLA, sp.

A species of *Modiola* occurs at Káteru, but in too fragmentary a state for description. Impressions of this genus, as well as of *Lima*, abound at Pangadi.

ARCA STRIATULA, sp. nov. Pl. IX. figs. 45 *a*, 45 *b*.

A. testa parva, ovato-oblonga?, subdepressa, tenuissime longitudinaliter striata; cardine subrecto, multidentato; margine integro. Long. ·3; lat. ·5 (?) unc.

Káteru, rare. The only specimen found is imperfect.

NUCULA PUSILLA, sp. nov. Pl. IX. fig. 46.

N. testa minima, lævigata, ovato-transversa, obliqua, valde inæquilaterali; dentibus minutissimis. Long. ·04; lat. ·05 unc.

Káteru, rare. A delicate little shell. The figure is magnified.

LUCINA PARVA, sp. nov. Pl. IX. fig. 47.

L. testa minuta, tenui, suborbiculari, convexiuscula, concentrice striata; dente laterali antico sat conspicuo. Long. ·14; lat. ·15 unc.

Káteru, rare, only a single valve having been found.

LUCINA (KELLIA?) NANA, sp. nov. Pl. IX. fig. 48.

L. testa minima, subtrigono-orbiculari, lævigata, subcompressa. Long. ·09; lat. ·09 unc.

Káteru, somewhat rare. The genus is doubtful, as the hinge cannot be seen.

CORBIS ELLIPTICA, sp. nov. Pl. IX. fig. 49.

C. testa elliptica, subventricosa, solida, cancellata; lamellis transversis crebris, ad marginem ventralem crebrioribus, antice posticeque plicato-crispis; margine intus crenulato. Long. 1·7; lat. 1·9 unc.

Káteru, rather frequent. Of this shell there are young specimens which, by their greater thinness and transverseness, vary from the typical form of the species as much as the *C. lamellosa* of Deshayes differs from his *C. pectunculus*.

CORBICULA INGENS, sp. nov. Pl. IX. fig. 50.

C. testa subæquilaterali, transversim ovato-rotundata, convexiuscula, concentrice striata; natibus subcrassis, antrorsum incurvis: valvæ dextræ dentibus cardinalibus duobus, posteriore magno; lateralibus lamellosis, striatis, parum arcuatis, perlongis, posteriore longiore. Long. 2·08; lat. 2·3 unc.

Káteru and Pangadi, frequent. This shell is remarkable for its size. The subdivision of *Cyrena* to which it belongs occurs in the rivers of India at the present day. Among my specimens there may be another species, thicker and more inequilateral.

CARDITA VARIABILIS, sp. nov. Pl. IX. figs. 51 *a*, 51 *b*, 51 *c*.

C. testa solida, subquadrato-ovata vel oblique subrotunda; costis circiter viginti, convexis, geniculato-nodulosis; nodulis ad marginem ventralem atque posteriorem obsoletis; costarum interstitiis longitudinaliter sulcatis; natibus prominentibus interdum valde gibbosis, incurvis; margine profunde lateque crenato. Long. 1·93; lat. 1·75 unc.

Káteru, common, and very variable in form.

CARDITA? PUSILLA, sp. nov. Pl. IX. fig. 52.

C. testa minima, suborbiculari, tenui; costis circiter 12, convexis. Long. ·07; lat. ·06 unc.

Káteru, rather rare. Genus somewhat doubtful.

CYTHEREA ORBICULARIS, sp. nov. Pl. X. fig. 53.

C. testa orbiculari, inæquilaterali, convexiuscula, solida. transversim tenuiter striata; natibus obliquis, prominentibus. Long. 1·1; lat. 1·1 unc.

Káteru, rather rare.

CYTHEREA WILSONI, sp. nov. Pl. X. fig. 54.

C. testa ovato-trigona, subæquilaterali, complanata, transversim tenuissime striata; natibus minimis. Long. ·7; lat. ·8 unc.

Káteru, frequent. Named after the Rev. Dr. Wilson of Bombay, the distinguished orientalist.

CYTHEREA WAPSHAREI, sp. nov. Pl. X. fig. 55.

C. testa ovata, subtrigona, convexiuscula, inæquilaterali, tenuiter striata; natibus parvis. Long. ·6; lat. ·7 unc.

Káteru, rather rare. Named after Major Wapshare.

CYTHEREA RAWESI, sp. nov. Pl. X. fig. 56.

C. testa ovata, convexa, solida; striis accretionis irregularibus; natibus prominentibus. Long. ·86; lat. ·91 unc.

Káteru, rather rare. Named after Mr. Rawes.

CYTHEREA JERDONI, sp. nov. Pl. X. fig. 57.

C. testa ovata, convexiuscula, inæquilaterali, postice producta, tenuiter striata; natibus prominulis. Long. ·93; lat. 1·1 unc.

Káteru, not unfrequent. This species somewhat resembles *C. Wilsoni*; but it differs from it in its greater thickness, the inequality of its sides, and the shape of both its anterior and posterior margins. Named after T. C. Jerdon, Esq., of the Madras Medical Service, and a distinguished naturalist.

CYTHEREA ELLIPTICA, sp. nov. Pl. X. fig. 58.

C. testa elliptica, transversa, convexa, inæquilaterali, ad marginem ventralem transversim sulcata; natibus parvis. Long. ·8; lat. 1·0 unc.

Káteru, rather rare.

CYTHEREA HUNTERI, sp. nov. Pl. X. fig. 59.

C. testa rotundato-elliptica, convexa, inæquilaterali, ad marginem ventralem transversim sulcata; natibus minimis. Long. ·6; lat. ·73 unc.

Káteru, rare.

TELLINA WOODWARDI, sp. nov. Pl. X. fig. 60.

T. testa ovato-suborbiculari, subæquilaterali, compressiuscula, concentrice subtiliter striata; margine ventrali convexo, dorsali utrinque subdeclivi, antice paululum longiore; natibus parvis, acutis; flexura satis conspicua. Long. ·47; lat. ·58 unc.

Káteru, rare. Named after S. P. Woodward, Esq., the eminent naturalist, who directed my attention to it, and to whom I am under great obligations for his advice on various points in drawing up this paper.

PSAMMOBIA JONESI, sp. nov. Pl. X. fig. 61.

P. testa oblongo-ovata, inæquilaterali, compressiuscula, transversim tenuiter striata; margine ventrali subrecto, dorsali utrinque subdeclivi, postice longiore; extremitate antica rotundata, postica obtuse angulata; natibus parvis. Long. ·57; lat. ·87 unc.

Káteru, somewhat frequent. Named after T. Rupert Jones, Esq.,

the able Assistant-Secretary of the Geological Society, to whom I have been deeply indebted on many occasions.

CORBULA OLDHAMI, sp. nov. Pl. X. figs. 62 *a*, 62 *b*.

C. testa ovato-oblonga, gibbosa, subæquivalvi, postice rotundata, antice angulato-acuminata, transversim tenuiter striata. Long. ·5; lat. ·76 unc.

Káteru, rather rare. This species bears a considerable resemblance to *Potamomya* or *C. ochreata* of Hinds, which inhabits streams in Brazil at the present day. Dedicated to Dr. T. Oldham, the eminent superintendent of the Geological Survey of India.

CORBULA SULCIFERA, sp. nov. Pl. X. figs. 63 *a*, 63 *b*.

C. testa valva minore, subtrigona, gibbosissima, transversim profunde sulcata; margine ventrali valde et irregulariter arcuato. Long. ·87; lat. ·9 unc.

Káteru, rare.

Shells from the freshwater strata of the Narbaddá Territory.

BULIMUS OLDHAMIANUS, sp. nov. Pl. X. figs. 64 *a*, 64 *b*.

B. testa ovato-conica, inflata; anfractibus 6, convexis, sutura satis impressa separatis; apertura ovata, superne angulata; columella inferne contorta, superne dente sive tuberculo calloso munita; labro reflexo. Long. ·53; lat. ·3 unc.

Dedicated to Dr. Oldham.

PISIDIUM MEDLICOTTIANUM, sp. nov. Pl. X. figs. 65 *a*, 65 *b*, 65 *c*.

P. testa parva, ventricosa, subæquilaterali, concentrice tenuiter striata sulcisque 5 ornata; natibus prominulis. Long. ·12; lat. ·12 unc.

With this species I have much pleasure in associating the name of the Messrs. Medlicott of the Indian Geological Survey.

The two shells last-described are found in the Narbaddá territory. Correct drawings of them have lately been furnished to me by my friend Dr. Oldham. *Pisidium Medlicottianum* occurs also at Mekalgandi Ghát in the Hyderabad territory, whence I obtained a cast some years ago.

P.S.—Since the preceding remarks were in type, I have been favoured with a proof-sheet of the forthcoming Report of the Indian Geological Survey on the Narbaddá District. Dr. Oldham takes credit to the Survey for having long since suggested the age of the Mahadewa sandstone. The reader, however, will have seen that my view of these beds is somewhat different from Dr. Oldham's, as he holds them to be possibly "the equivalent of the Nummulitic limestone*;" whereas I find them *in situ* below the Physa-deposit, and therefore they must be at least as old as the Lower Eocene. That they cannot be much older is an inference from the discovery in them of a *Paludina* similar to one in the Intertrappean deposit of Central India. To the opinions of the Survey on this latter rock, while they were unpublished, I did not think it right to allude; but now that they have been given to the world, I must be pardoned for expressing a doubt as to its being, in any part of Central India, of Wealden age.

* Mem. Geol. Surv. of India, vol. i. p. 171.

Wherever our intertrappean deposit is fossiliferous, there the same genera and species of shells occur, not to say that they are also met with in the subtrappean strata along with Pachydermatous bones. On Sitábaldi Hill we have the intertrappean shell-bed near the top, and the Mahadewa sandstone at the base. Now, were we to adopt the Survey's view of the age of these two rocks, we should have the Wealden above the Nummulitic formation. Dr. Oldham considers it unlikely that *Physa Prinsepii* should be preserved in the strata near Rájámandri; but no improbability will be felt when it is remembered that such a fragile shell as *Psammobia Jonesi* and others still more delicate have been preserved. In adopting his *à priori* mode of reasoning, my friend must have forgotten that a veritable *Physa Prinsepii* was discovered at Panga*d*i in the same block with marine shells*; and I may add that I saw it with my own eyes before Mr. A. Schlagintweit (to whom reference is made) could bear similar testimony.

Notes on some Fossil Insects from Nágpur.
By Andrew Murray, Esq., F.R.S.E., &c.

The specimens placed in my hands (thirteen in number) all belong to the order *Coleoptera*.

They chiefly consist of single elytra; in one case of two together, although somewhat crushed out of position; and in another, of a beautifully preserved abdomen. The tribes to which they belong (so far as decipherable) are the *Buprestidæ* and *Curculionidæ*; but I cannot identify any as belonging to living modern genera, much less species. This is not to be wondered at, when we consider that, although in most cases it might not be very difficult to determine the genus and even the species of *known recent insects* by actual comparison of such fragments as we have here, it would be quite impossible to determine with accuracy the genera of new species (however recent and fresh), although we might easily enough fix upon the tribe or family to which they belong. But, if to the difficulty arising from the fragmentary state of the materials be added that such new species by being fossilized are deprived of all colour, have lost their natural consistency, and generally have nothing left but the outline of the fragment with a few faint traces of their original markings, it will easily be seen that any opinion (worth having) on the subject must be given with great caution, and must be very much confined to a general indication of the whereabouts of the animal in the series.

So qualified, the opinion which I have formed on the specimens is as follows:—

No. 1 (Pl. X. fig. 66).—A well-preserved elytron from Tákli, found by Dr. Rawes (*Buprestidæ—Lomatus Hislopi*, Murray).—Elytron depressed and approaching to the form of the elytron in *Phænops*, turning in with an obtuse angle near the apex, and the outline thence continuing nearly straight to the apex. It is now

* Quart. Journ. Geol. Soc. vol. xi. p. 365.

almost smooth, but has been striated, though not deeply; and there is the appearance of a faint wide reticulation across the interstices, which are impunctate.

There have been seven striæ and a short sutural one; the third, fourth, and fifth intervals appear a little more prominent than the rest, but none of them assume the form of strongly marked costæ predominating over the rest; the striæ (judging from a short indication at the apex) have been punctate; they are straight, and run down from the base to the apex or margin without curve; there is a very marked reflexed margin, commencing a little below the shoulder and continuing to the apex. At the shoulder, and for some distance after, the margin of the elytron is inflexed, below the reflexed portion. The suture is sloped away a little at the base; from which we may infer that the scutellum was not a small square or rounded one encroaching on the elytron, as in many genera of *Buprestidæ*, but rather triangular, or perhaps invisible, as in *Chrysochroa*, &c. Judging from the texture, it is probable that the elytron had a metallic lustre. There is no appearance of serration or emargination at the apical margin.

Length of elytron, 5 lin.; breadth, $1\frac{3}{4}$ lin.

On the whole we have nothing corresponding to this elytron in existing Buprestidæ, nor is there anything in Mr. Westwood's, or other authors' figures of fossil insects which I have seen, corresponding to it; and as it is sufficiently well-marked to allow of other specimens being identified with it, and even referred to it as a genus, I would propose to constitute a new genus for it under the name of *Lomatus* (from λῶμα, a margin, referring to the margined elytra); and I add the specific name *Hislopi*, in honour of Mr. Hislop, to whom, along with Mr. Hunter, we chiefly owe the discoveries in geology made in the Nágpur district.

No. 2 (*Buprestidæ?*).—Crushed basal half of the elytron of apparently a Buprestidous insect, but in too bad a state to be decipherable or describable.

No. 3 (*Buprestidæ?*).—A portion of the apex of an elytron bearing punctured striæ. The striæ straight, except the exterior one, the punctures transverse; the apex angular, as in *Lomatus Hislopi* (No. 1), and a slight raised margin; but the fragment is too small and too indistinct to allow much to be said about it. It is obviously a portion of a much smaller insect than the two preceding.

The size of the present insect might be about 3 lines, that of the preceding about 7 or 8 lines.

No. 4 (*Buprestidæ?*).—This is a linear fragment apparently of two elytra crushed into a position at right angles to each other, and then again crushed into another angle longitudinally. We have neither base, nor apex, nor margin. We neither know its length, nor its breadth, nor its form. All we know is, that the elytron must have been more than half an inch in length, certainly more than $1\frac{1}{2}$ lines in breadth (judging from the crushed portion, probably more than 3 lines in breadth); that the elytra were punctate-striate, and that

the striæ had a tendency to run two and two together. It must have been a larger insect than any of the others we have, and more probably Buprestidous than anything else.

No. 5 (*Curculionidæ—Meristos Hunteri*, Murray) (Pl. X. fig. 67). —A beautifully preserved small abdomen, and a slight view of the margin of the elytron. The legs are wanting; but the cavity for the joint of the posterior legs remains, showing their position. The abdominal segments are five—two broad ones at the base, two narrow ones towards the apex, and a broad apical one, each lower than the preceding segment. The texture has been hard, and probably not pubescent; and the surface is coarsely punctured. The elytra seem round, and are coarsely punctate-striate.

Some of the recent *Curculionidæ* have very nearly this arrangement of the abdominal segments (*Cherrus*, an Australian genus, for instance); and after a careful review of the different characters in different tribes, I have come to the conclusion that this is a *Curculio*, though to what family it should be referred I do not pretend to say; still, as it is distinct, I have proposed the generic name *Meristos* for it, alluding to its divisions, and the specific name *Hunteri*, in honour of Mr. Hunter.

Length, $1\frac{1}{4}$ lin.; breadth, $\frac{3}{4}$ lin.

No. 6 (*Curculionidæ*).—A single elytron, either curved out of shape or singularly bent in at the scutellum, slightly costate, but apparently not punctured.

Length of elytron, $2\frac{1}{4}$ lin.; breadth, 1 lin.

No. 7 (*Curculionidæ*).—A small, straight, narrow elytron, deeply punctate-striate; the striæ geminate, and the third and fourth united near the apex. Has some resemblance to the form of the elytra on the Phyllobiidæ (of which, one genus, the *Myllocerus*, is East Indian at the present day), but was apparently of a harder consistence.

Length of elytron, 1 lin.; breadth, $\frac{1}{2}$ lin.

No. 8 (*Curculionidæ*).—A single elytron of an insect, apparently allied to *Myllocerus*, punctate-striate, the interior striæ appearing to unite with the opposing striæ towards the apex. The texture would appear not to have been very hard.

Length of elytron, 3 lin.; breadth, 1 lin.

No. 9 (*Curculionidæ*).—A single elytron, apparently belonging to the same group, punctate-striate; the interstices are slightly raised, and a delicately punctured line runs down them, so that it gives the elytron the appearance of having each stria separated by two delicate costæ.

Length, $2\frac{1}{2}$ lin.; breadth, $\frac{3}{4}$ lin.

No. 10 (*Curculionidæ*).—Portion of a single crushed elytron, apparently belonging to the same group, punctate-striate, the striæ joining the opposing ones at the apex,—viz. the outmost joining the sutural stria, the second joining the second outmost, and so on.

Length of elytron, probably 3 lin.; breadth, $\frac{1}{2}$ lin.

No. 11 (*Curculionidæ*).—A fragment of a small elytron, pretty

well defined, punctate-striate; nine striæ, the sixth and seventh apparently enclosed by the rest. (Fig. 68.) It corresponds more closely with the elytron of an undescribed genus from Australia than any other which I have seen.

Length, $1\frac{1}{4}$ lin.; breadth, $\frac{1}{3}$ lin.

No. 12 (*Curculionidæ*).—A single elytron, somewhat flat on the surface, with occasional depressions; base straight; the margin inflexed, and extending down only for a short space; deeply punctate-striate; nine or ten striæ (the margin being not clearly decipherable), the fourth and fifth, third and sixth, &c. uniting towards the apex. (Fig. 69.)

This is a somewhat puzzling specimen, the flat surface and rather hollow inflexure of the margin suggesting a Buprestidous affinity; but the deep punctation, depressions on the surface, and arrangement of the striæ show a greater affinity with the Curculionidæ, and remind one of a small *Minyops*.

Length of elytron, 2 lin.; breadth, $\frac{1}{2}$ lin.

No. 13 (*Curculionidæ*).—Two elytra together, but obviously crushed; at first sight, perhaps one might be disposed to view them as the remains of a Heteromerous insect. But I think it is the crushing which gives this appearance, and that it is really a Curculionidous insect with the inflexed and rounded margins of the elytra squeezed out flat. Pushed out of shape as it is, all that can be said is that there are eight striæ visible (there may be one or two more not seen); the striæ are delicately punctate, the punctures being minute and wide apart; and the fourth and fifth, third and sixth striæ are united, as is common among the Curculionidæ. (Fig. 70.)

Length of elytron, $2\frac{1}{4}$ lin.; breadth, 1 lin.

I cannot take leave of this interesting collection without drawing attention to the fact that these insects are all of small, and most of them of minute size. This is quite in accordance with previous discoveries of fossil insects, which have mostly been found of minute size; and I think, so far as may be guessed at from these specimens, we are warranted in saying that the Entomological Fauna of Nágpur, at the era of these fossils, was probably smaller than that of the present day,—at all events, certainly not larger; for although it is now well known that in all parts of the world, tropical as well as temperate, minute insects predominate, still a chance collection of a dozen flotsam and jetsam insects in the present day would, I think, have furnished some larger species than any now before me. I would also wish to observe that, although all the insects are minute, the only species which give any indication of temperature (the *Buprestidæ*) point more to a warm climate than a temperate one. The *Curculionidæ*, to which the greatest number belong, give no indication either way, being found (of the size in question) equally in temperate and tropical regions.

Note on the Fossil Cypridæ from Nágpur.
By T. Rupert Jones, Esq., F.G.S.

In the Trans. Geol. Soc. 2 ser. vol. v., Mr. Sowerby has described (in the "Explanation of the Plates") two species of *Cypris* from the fossiliferous chert of the Sichel Hills; namely *Cypris cylindrica* (*op. cit.* pl. 47. fig. 2), and *C. subglobosa* (fig. 3). These occur more especially between Munoor and Nutnoor in company with *Unio*; and near Nutnoor in vast numbers, associated with abundance of *Gyrogonites* and some *Limnei*. At Chickni also, nearer to Nágpur, they occur with *Melania*, *Paludinæ*, and *Limnei*. I have examined the original specimens presented by Dr. Malcolmson to the Geological Society, and have not been able to detect among them clear evidences of any other species of Entomostraca.

The specimens procured by the Rev. Messrs. Hislop and Hunter from the neighbourhood of Nágpur comprise a large variety of Entomostraca, and frequently the carapaces are perfectly preserved,—a condition very rare in the materials which Mr. Sowerby examined. I have not, however, seen from Nágpur any rock so full of these little fossils as some of the chert from near Nutnoor is.

1. *Cypris cylindrica*, Sow.—This appears to be tolerably abundant in the freshwater deposits near Nágpur. The largest individual I have met with is about $\frac{1}{20}$th inch in length; nor have I seen larger ones in the chert from the Sichel Hills. Sowerby's figure indicates $\frac{1}{8}$th inch for the size; but perhaps this may have arisen from an error of the engraver. Minute individuals also occur; also a markedly curved specimen, constituting perhaps a variety. *C. cylindrica* has living representatives in the fresh waters of Nágpur. See Dr. Baird's description of recent Entomostraca from Nágpur in the Zool. Proc. 1859.

2. *Cypris subglobosa*, Sow., is very abundant among the materials submitted to me by Mr. Hislop. Ordinarily the specimens have a length of about $\frac{1}{16}$th inch, with a diameter of $\frac{1}{20}$th; and the smallest are about $\frac{1}{45}$th inch long. A few individuals differ from the common form in their proportions; one being $\frac{1}{12}$th inch long, by $\frac{1}{20}$th thick, and has the extremities nearly equally acute: this is probably a variety. The largest *C. subglobosa* which I have seen was collected by Mr. Hislop; it is $\frac{1}{6}$th inch long, $\frac{1}{12}$th high, and $\frac{1}{10}$th thick.

Most of the individuals are rather more strongly arched, or even angular, on the back, than Sowerby's figured specimen, and the anterior extremity is more distinctly compressed. The ornament, appearing under a pocket-lens to consist of punctate marks, is really a fine reticulation, which passes into wrinkles on the ventral region.

C. subglobosa belongs to H. de Saussure's subgenus *Chlamydotheca*, characterized by a doubled margin at the extremities of the valves. The figures given by Dr. Baird in the Zoological Society's Illustrated Proceedings of the variety of this species now living in ponds of Nágpur well represent this feature. As Dr. Baird's recent specimens differ from the fossil forms in having a less gibbous

back, a somewhat convex ventral face, and apparently a different number of lucid spots, and as they want also the longitudinal wrinkles of the ventral surface, they must be at least varietally distinct.

Dr. Carter has recognized in some fossil *Cyprides* from Bombay the marginal appendix, or "lunate fossa," of the anterior extremity.

3. *Cypris Hislopi*, spec. nov. Pl. X. fig. 71.

This has a somewhat triangular carapace, much compressed towards each extremity, and is not unlike *C. celtica*, Baird, but is more obtuse at the hinder end. It is $\frac{1}{8}$th inch long, and $\frac{1}{12}$th high at the anterior hinge, which is more acute in the old individuals than in the young. The surface is brownish, with delicate wrinkly reticulations, passing into punctation.

4. *Cypris Hunteri*, spec. nov. Pl. X. fig. 72.

This is a rarer form. It is of the same size as *C. Hislopi*, but differs materially in form, being nearly oblong, subcylindrical, thick, and bulky; whilst the latter is subtriangular and comparatively flat. I have not seen a well-preserved exterior. Small specimens less than $\frac{1}{12}$th inch occur.

5. *Cypris strangulata*, spec. nov. Plate X. fig. 73.

This *Cypris* is somewhat oblong in profile, but rounded behind, and obliquely rounded in front, irregularly ovate seen from above, triangular on end-view, and constricted in the anterior region of each valve by an oblique linear depression, commencing behind the anterior hinge, and curving forwards and downwards. The carapaces vary considerably in the gibbosity of the valves. Ordinary specimens are $\frac{1}{24}$th inch long, $\frac{1}{45}$th high, and $\frac{1}{30}$th thick.

6. In a whitish siliceous rock from Chickni, presenting innumerable cavities left by decomposed *Cyprides* and other minute fossils, we have numerous Entomostracous valves, mostly much flattened, some of which are referable to *C. cylindrica*; but the majority present such protean proportions, varying from orbicular to oval and oblong, as we trace them from size to size, that I hesitate to separate them specifically. They all appear to have partial marginal rims, and to be smooth. One of Dr. Baird's figures of *Cypris dentato-marginata* is not unlike some of these specimens from Chickni.

7. From Káteru (from an estuarine deposit) we have a few very small specimens of a subcylindrical form, which are relatively shorter and thicker than *C. cylindrica*, and have a somewhat angulated hinge-line. These may belong to the *Cytheridæ*.

8. In a piece of rock from Pungadi there is a trace of an Entomostracous carapace, possibly a *Cythere*.

9. Some drawings of Entomostracous carapaces, from the Intertrappean beds of the Narbaddá Territory, have been shown me by the Rev. S. Hislop. The drawings have been made from specimens collected by the Geological Survey of India. I can only suggest that probably *Cypris subglobosa* and *C. Hislopi* are among the specimens referred to.

Fossil Freshwater Shells from the Nágpur Territory.

Melania quadrilineata, *Sow.*		
Hunteri, spec. nov.	Pl. V.	f. 1.
Paludina normalis, spec. nov.	„	f. 2 *a*, 2 *b*.
Deccanensis, *Sow.*		
Wapsharei, spec. nov.	„	f. 3 (magnified).
acicularis, spec. nov.	„	f. 4.
Pyramis, spec. nov.	„	f. 5.
subcylindracea, spec. nov.	„	f. 6.
Sankeyi, spec. nov.	„	f. 7.
Takliensis, spec. nov.	„	f. 8 *a*, 8 *b*.
soluta, spec. nov.	„	f. 9.
conoidea, spec. nov.	„	f. 10.
Rawesi, spec. nov.	„	f. 11 *a*, 11 *b*.
Virapai, spec. nov.	„	f. 12 *a*, 12 *b*.
Valvata minima, spec. nov.	„	f. 13 (magnified).
unicarinifera, spec. nov.	„	f. 14.
multicarinata, spec. nov.	„	f. 15 *a*, 15 *b*.
decollata, spec. nov.	„	f. 16 *a*, 16 *b*.
Nagpurensis, spec. nov.	„	f. 17.
Limnæa oviformis, spec. nov.	„	f. 18 *a*, 18 *b*.
subulata, *Sow.*	„	f. 19.
attenuata, spec. nov.	„	f. 20.
Telankhediensis, spec. nov.		
var. peracuminata	„	f. 21 *a*.
var. Radiolus	„	f. 21 *b*.
Spina, spec. nov.	„	f. 22.
Physa Prinsepii, *Sow.* (normalis)	„	f. 23 *a*.
var. elongata	„	f. 23 *b*, 23 *c*.
var. inflata	„	f. 23 *d*.
Unio Malcolmsoni, *Hisl.* (=U. tumida, *Sow.*)		
Deccanensis, *Sow.*	Pl. VI.	f. 24 *a*, 24 *b*, 24 *c*.
Hunteri, spec. nov.	„	f. 25.
mamillatus, spec. nov.	Pl. VII.	f. 26.
imbricatus, spec. nov.	„	f. 27 *a*, 27 *b*, 27 *c*.
Carteri, spec. nov.	„	f. 28.

Fossil Estuarine Shells from Rájámandri.

Fusus pygmæus, spec. nov.	Pl. VIII.	f. 29 (magnified).
Pseudoliva elegans, spec. nov.	„	f. 30 *a*, 30 *b*.
Natica Stoddardi, spec. nov.	„	f. 31.
Cerithium multiforme, spec. nov.	„	f. 32 *a*, 32 *b*, 32 *c*.
subcylindraceum, spec. nov.	„	f. 33 *a*, 33 *b*, 33 *c*, 33 *d*.
Leithii, spec. nov.	„	f. 34.
Stoddardi, spec. nov.	„	f. 35.
Vicarya fusiformis, spec. nov.	„	f. 36 *a*, 36 *b*, 36 *c*.
Turritella prælonga, spec. nov.	„	f. 37 *a*, 37 *b*, 37 *c*, 37 *d*.
Hydrobia Ellioti, spec. nov.	„	f. 38 (magnified).
Carteri, spec. nov.	„	f. 39 (magnified).
Bradleyi, spec. nov.	„	f. 40 (magnified).
Hemitoma? multiradiata, spec. nov.	„	f. 41 *a*, 41 *b* (magnified).
Ostrea Pangadiensis, spec. nov.	Pl. IX.	f. 42.
Anomia Kateruensis, spec. nov.		
var. suborbicularis	„	f. 43 *a*.
var. Modiola	„	f. 43 *b*.
Lima, sp.		
Perna meleagrinoides, spec. nov.	„	f. 44.
Modiola, sp.		
Arca striatula, spec. nov.	„	f. 45 *a*, 45 *b*.

Nucula pusilla, spec. nov.	Pl. IX.	f. 46 (magnified).
Lucina parva, spec. nov.	,,	f. 47 (magnified).
(Kellia ?) nana, spec. nov.	,,	f. 48 (magnified).
Corbis elliptica, spec. nov.	,,	f. 49.
Corbicula ingens, spec. nov.	,,	f. 50.
Cardita variabilis, spec. nov.	,,	f. 51 *a*, 51 *b*, 51 *c*.
pusilla, spec. nov.	,,	f. 52 (magnified).
Cytherea orbicularis, spec. nov.	Pl. X.	f. 53.
Wilsoni, spec. nov.	,,	f. 54 *a*, 54 *b*.
Wapsharei, spec. nov.	,,	f. 55.
Rawesi, spec. nov.	,,	f. 56.
Jerdoni, spec. nov.	,,	f. 57.
elliptica, spec. nov.	,,	f. 58.
Hunteri, spec. nov.	,,	f. 59.
Tellina Woodwardi, spec. nov.	,,	f. 60.
Psammobia Jonesi, spec. nov.	,,	f. 61 *a*, 61 *b*.
Corbula Oldhami, spec. nov.	,,	f. 62 *a*, 62 *b*.
sulcifera, spec. nov.	,,	f. 63 *a*, 63 *b*.

Fossil Shells from the Narbaddá Territory.

Bulimus Oldhamianus, spec. nov.	Pl. X.	f. 64 *a*, 64 *b*.
Pisidium Medlicottianum, spec. nov.	,,	f. 65 *a*, 65 *b*, 65 *c*.

Fossil Insects from the Nágpur Territory.

Lomatus Hislopi, *Murray*	Pl. X.	f. 66.
Meristos Hunteri, *Murray*	,,	f. 67.
Curculio ?	,,	f. 68.
Curculio ?	,,	f. 69.
Curculio ?	,,	f. 70.

Fossil Cypridæ from near Nágpur.

Cypris subglobosa, *Sow.*		
cylindrica, *Sow.*		
Hislopi, *Jones*	Pl. X.	f. 71 *a*, *b*, *c*.
Hunteri, *Jones*	,,	f. 72 *a*, *b*, *c*.
strangulata, *Jones*	,,	f. 73 *a*, *b*, *c*, *d*.

June 22, 1859.

ADJOURNED GENERAL MEETING.

The following communications were read:—

1. *Further Observations on the* Ossiferous Caves *near* Palermo. By Dr. Falconer, F.R.S., F.G.S.

[An abridgment of this Communication has been printed at page 99.]

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2. Joseph Prestwich, Esq., F.R.S., Treas. G.S., gave in a few words the results of the examination of the Bone-cave at Brixham in Devonshire.

The cave has been traced along three large galleries, meeting or

intersecting one another at right angles. Numerous bones of *Rhinoceros tichorhinus, Bos, Equus, Cervus tarandus, Ursus spelæus,* and *Hyæna* have been found; and several flint-implements have been met with in the cave-earth and gravel beneath. One in particular was met with immediately beneath a fine antler of a Reindeer and a bone of the Cave-bear, which were imbedded in the superficial stalagmite in the middle of the cave.

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3. *On a* Flint Implement *recently discovered at the base of some beds of* Drift-Gravel *and* Brick-earth *at* St. Acheul, *near* Amiens. By John Wickham Flower, Esq.

[Communicated by Joseph Prestwich, Esq., F.R.S., F.G.S.]

[Plate XI.]

The implement or weapon which I desire to bring under the notice of this Society, and a drawing of which accompanies these observations (Pl. XI.), was found by me about a month since, when, in company with Mr. Prestwich and other Fellows of this Society, I visited some gravel-pits near Amiens. When discovered, it was imbedded in a compact mass of gravel, composed of large chalk-flints much water-worn and rolled, and small chalk-pebbles. It was found lying at the depth of sixteen feet from the upper surface, and about eighteen inches from the face or outer surface of the quarry, to which extent the gravel had been removed by me before I found it. The bed of gravel in question forms the capping or summit of a slight elevation of the chalk. A section of this pit, which Mr. Prestwich lately exhibited to the Royal Society*, showed that the gravel presents here a thickness of about ten feet. Above this occurs a thin bed of coarse, white, siliceous sand, interspersed with small rounded chalk-pebbles; and above the sand is a layer of strong loam, of a red colour, which is now extensively worked for the purpose of making bricks. The remains of the Elephant, Horse, and Deer have been occasionally found in the gravel; and we found in the sand which rests upon it an abundance of land and freshwater shells, all of recent species. No fossils of any kind were discovered by us in the brick-earth lying on the surface. At the distance of a few hundred yards from the convent of St. Acheul are the remains of an ancient Roman cemetery. A large stone tomb is here left standing on the surface, the brick-earth having been cleared away from it; and here many Roman coins and bronze ornaments are found.

At St. Roch (about half a mile distant from St. Acheul), we also examined a quarry of flint-gravel, of precisely the same character, and, apparently, of the same period as that of St. Acheul. We procured from it two very fine tusks of the *Hippopotamus*, which had

* Proc. Roy. Soc. vol. x. no. 35. p. 51.

FLINT IMPLEMENT FROM AMIENS

FLINT IMPLEMENT FROM AMIENS.

been found twenty feet from the surface. These were but little rolled or broken; and it seems probable, therefore, that the same forces that transported these flint implements to their present position may also have deposited these remains of the *Hippopotamus*.

The first discovery of these flint instruments, as well in this quarry as in other localities in the Valley of the Somme, is due to M. Boucher de Perthes, of Amiens. It was with a view to verify by personal observation the result of his researches that our visit to St. Acheul and the neighbourhood was undertaken. Mr. Prestwich had, indeed, previously visited the spot, and had embodied the result of his researches in a paper which was read before the Royal Society in May last. He had not, however, succeeded in finding one of these implements *in situ*, although he had procured several of them from the labourers. It was only after labouring for several hours that I succeeded in disinterring the specimen in question.

The result of our examination perfectly satisfied us, as it had already satisfied Mr. Prestwich, of the frequent occurrence of these weapons or implements beneath the beds of loam, sand, and gravel which I have described. We not only found two good specimens of these implements, but we brought away upwards of thirty others, taken from the same pit; several of them are on the table. Some of these were found at about the same depth as that which I discovered, and some about four feet lower down. They were procured without difficulty from the labourers and their children. Mr. Prestwich, on the occasion of his first visit, in company with Mr. Evans, brought away about twenty specimens; and many others are to be seen in M. Boucher de Perthes's Museum. They are so common in the pit in question as to have acquired a trivial name, and are known by the workpeople as *langues de chat*.

There is one peculiarity in these implements which appears to deserve particular notice: they were evidently water-worn and rounded pebbles before they were formed into weapons or tools; and this, indeed, is just such a condition as we should expect to find. None but people destitute of iron would have been content to use such rude and uncouth instruments as these; and a people unprovided with iron would also have been unable to quarry the chalk for the sake of the flint imbedded in it, but would have been forced to content themselves with those fragments which lay scattered upon the surface, or but a little below it. If we examine the specimens closely, we find that, while the manufactured or worked surfaces (namely the cutting edges and the point) are nearly as sharp and clear as if worked yesterday, the portion left of the original, or, if we may so call it, the *natural* surface (that which has not been struck off in the course of manufacture) is often very much water-worn; and it also presents that peculiar discoloration usually found in flints long exposed to the influence of the atmosphere, extending to the depth of a quarter or an eighth of an inch, and probably due to some chemical change resulting from mechanical forces.

It would thus seem that those forces, whatever they may have been, by means of which these implements were carried into their

present position, were in operation but for a short period, since otherwise the sharp edges which they still retain would have been rounded and worn, if not altogether obliterated; and further, that the rolled and discoloured surface of the flint-pebbles with which they are associated (and from which indeed it seems probable that they were originally taken and fashioned) was due to some former change—the drift or gravel having subsequently been merely shifted from some other spot, bearing these implements with it, just as the loose ballast in the hold of a vessel is shifted and rolled from one side to another.

No one who attentively examines these implements can doubt that they are the products of human skill. Rude and uncouth as they may appear, that rudeness is probably not so much due to any deficiency of intelligence in the manufacturers, as to the want of iron or some other metals wherewith to work. Probably no workman who found himself destitute of metal tools would be able to produce from flint-pebbles more useful or elegant implements. Those who are familiar with the forms which are presented in those flints which are casually fractured will agree that it is almost impossible that even a single flint should be so fractured by accident as to assume the shape of these implements; but here we have a great number, all taken from a single quarry. Further, it will be seen that the original or natural surface is never retained where it at all interferes with the shape and symmetry of the weapon. Wherever it would have so interfered, chiefly on the sides and at the point, it has been chipped away; and thus there has been no waste of labour, nothing having been removed but that which was inconvenient. It will also be noticed that they are all formed after a certain rude but uniform pattern; they are worked to a blunt point at one end, with a rude cutting edge on each side, and a sort of boss at the other extremity, forming a handle or hand-hold. In order the better to form this double edge, a ridge is left running down the centre; and the edges have been formed by striking away the flint in splinters from each side, in a direction at right angles with, or a little oblique to, the axis, the base or under side being usually either flat, or but slightly convex.

The discovery of these implements under the circumstances indicated cannot fail to suggest many interesting inquiries. We should all desire to know something more concerning the persons by whom, and the purposes for which, they were fabricated,—how it happened that so many of them were brought together in so small a space,—and how it is that no remains have hitherto been found of those by whom they were made and used. These, however, are speculations which seem to belong to the province of archæology rather than to that of geology; and they are only now alluded to by way of suggestion that topics of such importance and interest are well deserving the investigation of archæologists.

November 2, 1859.

William Fryer, Esq., 10, Marlborough-hill Gardens, St. John's Wood; Henry Salmon, Esq., 38, Coburg Street, Plymouth; and the Rev. Samuel George Phear, M.A., Emmanuel College, Cambridge, were elected Fellows. Dr. Ferdinand Roemer, Professor of Geology and Paleontology at the University of Breslau, was elected a Foreign Member.

The following communications were read:—

1. *On the* Passage-beds *from the* Upper Silurian Rocks *into the* Lower Old Red Sandstone, *at* Ledbury, Herefordshire. By the Rev. W. S. Symonds, F.G.S., Rector of Pendock.

The transition, or passage-rocks, which connect the Upper Silurian deposits with the basement-beds of the Old Red Sandstone epoch, are most interesting to the geologist; and as a very remarkable section of these rocks is now visible on the line of railway near Ledbury, in Herefordshire, a few notes with a sketch and section may be acceptable.

In my communication on "The Old Red Sandstone of Herefordshire," published in the Edinburgh New Philosophical Journal (April 1, 1859, p. 232), I expressed my opinion that the Ludlow sections on the horizon of the passage-beds above the Downton Sandstone are broken by faults, and that the true succession is therefore destroyed. I had come to this determination long before the beds now developed in the railroad-cutting at Ledbury were exposed to view; and, having again lately visited Ludlow, and compared the passage-rocks of that district with those of Ledbury, I am convinced that nowhere perhaps in the world is there such an exhibition of passage-beds presented to the eye of the geologist as at the Ledbury tunnel, on the Worcester and Hereford Railway. Fortunately most of the passage-beds are laid open to the sunlight, and the important points exposed.

When engaged upon the section, I was accompanied by my friends Mr. Edmond Richards, and the Messrs. Ballard, the Engineers on the Worcester and Hereford Railway, to whom I return my best thanks for their hearty and efficient cooperation.

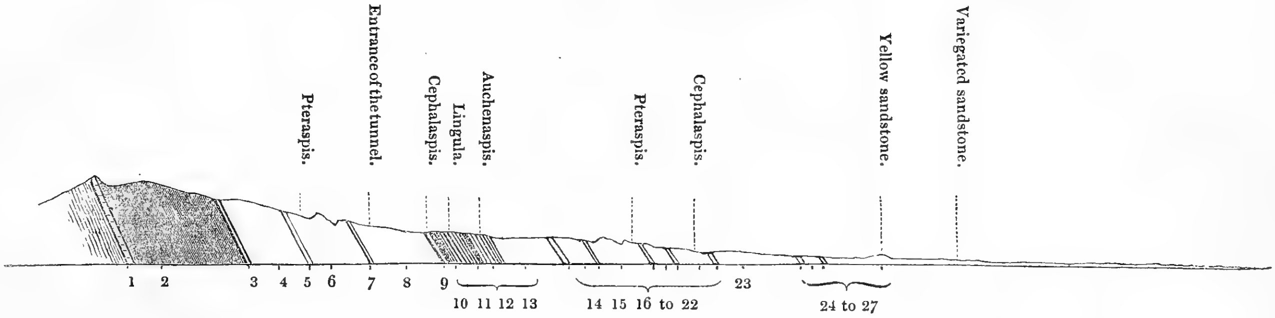
The strata dip at an angle of 71° north-by-west. The accompanying sketch (see fig. on p. 194) gives a view of the beds looking from the Ledbury side towards Dog Hill, and facing the tunnel-mouth.

The beds exposed range, in descending order, from rocks of the age of the Lower Old Red Sandstone (No. 27 of section) to rocks that pass into the uppermost Silurian or Downton beds (No. 3), and include the celebrated bluish-grey rocks of the Ludlow section, with similar fossil fish, crustaceans, and shells.

Aymestry Rock (No. 1 of section).

When I last visited the tunnel (a fortnight since, in company with Sir Charles Hastings, Major Tennant, and the Rev. J. Pearson), the

Section of the Railway-tunnel near Ledbury.



27. Marl, with some bands of sandstone.
26. Grey rock.
25. Marl.
24. Grey rock.
23. Marl.
22. Grey rock.
21. Marly rock, with *Cephalaspis*.
20. Grey rock.
19. Marly rock.
18. Grey rock.
17. Marly rock, with *Pteraspis*. Some of the hard bands finely laminated.
16. Grey rock.
15. Marl.
14. Grey rock.
13. Marl.
12. Grey marl and grey rock. { Red and blue marls. Yellowish-grey sandstone, 18 in. Greenish shale, 6 in. Dark-grey sandstone, 8 in. Deep-red micaceous shale. }
11. Purple sandstone.
10. Purple marls and shale.
9. Grey shale.
8. Red marl.
7. Red sandstone.
6. Red marl with *Pteraspis*.
5. Mottled marls.
4. Red marls, with grey spots.
3. Downton sandstone, with red, grey, and yellow marls.
2. Upper Ludlow rocks, about 140 feet.
1. Aymestry rocks, about 10 feet thick.

"heading" was driven through a considerable thickness of the Ledbury equivalent of the Aymestry limestone. The characteristic *Pentamerus Knightii* has been discovered by Henry Brooks; and abundance of the *Rhynchonella Wilsoni*, with *Strophomena euglypha* and *Atrypa reticularis*, pervade the here impure limestone.

Upper Ludlow Rock (No. 2).

The workmen have discovered that a *shale* at the surface becomes a *rock*, and an exceedingly hard rock, in a tunnel; nevertheless these beds are not so intractable as the Aymestry deposits, and soon weather when exposed to the atmosphere. Many typical fossils are known, as *Chonetes lata*, *Discina rugata*, *Serpulites longissimus*, and *Cornulites serpularius*, &c. Some of the beds contain nodular concretions of iron-pyrites.

The bone-bed, at the summit of the Upper Ludlow Rock, has not as yet been discovered at Ledbury.

Downton bed (No. 3).

The Downton Castle building-stone is but thinly developed in the Ledbury tunnel, and the yellow character is not so persistent, while, owing to a lateral wrench running from east to west, the interpretation of these rocks is rendered somewhat obscure. Mr. Collingwood, a gentleman visiting Ledbury for the purpose of geologizing, has detected the small *Lingula* so characteristic of these strata, and, as I think, evidently a different species from the large *Lingula* of the red and grey beds higher in the series, the *Lingula cornea*. I trust that future excavations, and a brighter light than that obtained from tallow-dips, will yet enable us to determine whether certain reddish marly beds on this horizon are in position, or let in by a fault.

Red and Mottled Marls with their Sandstones (Nos. 4 to 8 of section).

From the Downton beds to the entrance of the tunnel in the Red Marls (No. 8), we find a series of red and mottled marls and sandstones, which have furnished no fossils excepting a large *Lingula* and fragments of *Pteraspis* or *Cephalaspis*. All these strata are clearly conformable to the Downton beds below, and the greyish-blue grits and shales (see Nos. 9 and 12 of section).

Grey Shale and thin Grit (No. 9).

This thin band is conformably underlain by red marls, and conformably surmounted by red and purple shales and sandstones. I have in my possession a portion of the head of a large *Cephalaspis*, (*C. Murchisoni*) and a pincer of a *Pterygotus*, both of which were discovered and treasured up by Henry Brooks of the Homend, Ledbury, a working shoemaker, and an indefatigable geologist. I can recommend him as a most efficient local guide to the geology of the district.

Purple Shales and thin Sandstones (Nos. 10 & 11).

These rocks furnish a striking background to the grey rocks next to be described, and which stand out in bold relief. No time, however, should be lost if geologists wish to behold this picturesque section; for the pickaxe and shovel will soon destroy a succession of

escarpments beautiful to look upon, and reduce to the uniformity of a railroad-cutting an exhibition of a peculiar series of rocks which the geologist has long hoped to behold *in situ*. He may never have the opportunity again!

Grey Marl passing into red and grey marl and bluish-grey rock (Auchenaspis-beds) (No. 12).

I consider these beds as the equivalents of those liver-coloured and greyish rocks, with the remains of crustaceans and fish, described by Mr. Lightbody in the railroad-cutting at the railway-bridge, near Ludlow. The mineral character of the Ledbury deposits differs considerably from those of Ludlow, hard stone being much more developed at Ledbury, whereas at Ludlow *shale* is the character of the deposit. The Ludlow beds, however, contain "pockets" of stone, enveloped in shale, which I could not distinguish from the thick-bedded building-stone of Ledbury, that contains such an abundance of the *Auchenaspis Salteri*, Egerton, a figure of which is given in the Quarterly Journal of the Society, vol. xiii. pl. 9. fig. 4, and by Sir Roderick Murchison in 'Siluria,' new edit. p. 155. In the Ledbury beds, Henry Brooks has also detected portions of the fossil fishes *Plectrodus*, *Cephalaspis*, *Pteraspis*, and *Onchus*. *Pterygotus Ludensis* also occurs, with a large *Lingula*. The *Auchenaspis* is so abundant, that as many as four heads have been found upon a small slab a foot in diameter; the tail and body of this fish are as yet unknown. The Auchenaspis-beds at Ledbury are 15 feet thick, and pass upwards conformably into a series of red marls, with yellowish-grey and pink sandstone, containing the relics of *Pteraspis* and *Cephalaspis*, which are undoubtedly the base of the Cornstone series of the Old Red Sandstone. Sir R. I. Murchison ranks the Cornstone-beds of the Old Red Sandstone as the base of the series; and undoubtedly, in some instances, thin Cornstones are mineralogically developed near the bottom of the Old Red; but the Cornstones of Herefordshire, as described by Sir Roderick in the 'Silurian System', the Cornstones of Wall Hills, near Ledbury, of Foxley, Whitfield, Ewyas Harold, Orcop, and Abergavenny are, I am convinced, at least two thousand feet above the Downton sandstone, or highest Silurian deposits.

The thick subcrystalline cornstones just alluded to are also, I believe, higher in the Old Red series than the thin bands, interstratified with sandstone, which are quarried near Leominster, at Leyster's Pole, and many other places, and the characteristic fossils of which are *Cephalaspis Lyellii*, *Pteraspis Lloydii*, and *Pter. Lewisii*. *Mineralogical* nomenclature, therefore, is inappropriate when applied to the *physical position* of rocks, and apt to mislead those not conversant with the mineralogical peculiarities of different districts.

The word "tilestones" (now happily abandoned by Sir R. Murchison) is altogether inappropriate as applied to the Ledbury rocks.

There is not a stone capable of being formed into a *tile*, from the Downton sandstone to the cornstones of Wall Hills; but there are

thin muddy marls over the Downton beds, which would have been tilestones had they sufficiently hardened, and which are doubtless the equivalents of the true tilestones.

I consider, therefore, the term "passage-rocks," as used by Sir R. Murchison in the last edition of 'Siluria,' to be a more appropriate appellation for these transition-beds, and one which allows to the palæontologist, as well as the physical geologist, a broad margin for the line of demarcation between the two great epochs of the Silurian and the Old Red.

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2. *On the so-called* Mud-volcanos *of* Turbaco, *near* Carthagena. By F. Bernal, Esq.

[In a letter* to Sir R. I. Murchison, F.G.S.]

(Abstract.)

Turbaco is a village, about fifteen miles from Carthagena, at an elevation of about 980 feet above the sea. At a distance of about three miles from the village, and at a rather higher elevation, in the midst of a forest, are some twenty or thirty conical hillocks, about 8 or 10 feet high, each with its little crater or orifice, about 2 feet in diameter. These are filled with a muddy water; and every two or three minutes a slight noise is heard, a bubbling-up of air or gas takes place, the muddy fluid runs over, and forms into cakes of blue clay. The water is quite cool, nor is there any present or anterior marks or vestiges of the action of fire or heat†.

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3. *On the* Coal-formation *at* Auckland, New Zealand. By Henry Weekes, Esq.

[Communicated by the President.]

(Abstract.)

The district is formed of stratified sandy clays, of Tertiary age; they vary in colour from white to light-red. The white clays contain beds of lignite, varying from a few inches to several feet in thickness. Sections of these beds are exposed along the banks of most of the tidal inlets with which the district abounds. In some places, near the hills, the lignite is seen to rest on trap-rock; elsewhere a shelly gravel underlies it.

At Campbell's farm a whitish sandstone lies on the lignite, and at the junction is hardened, and contains ironstone-nodules; these, when broken, yield remains of exogenous plants. A fossil resin is found abundantly in the lignite. On Farmer's Land the lignite is 16 feet thick, including a little shale; at Campbell's it is 7 feet thick, but thins away. There is some iron-pyrites in the lignite, but not sufficient to deteriorate its value as a coal. Similar coal has been found at Muddy Creek to the S.W.; at Mokau, about 100 miles to the south; and near New Plymouth.

* Dated British Consulate, Carthagena, New Granada, April 9, 1859.

† A sketch of these salses is given in Humboldt's 'Vues des Cordilleras.'

The Tertiary beds of Auckland are everywhere broken through by extinct volcanos, varying from 200 to 800 feet in height. The craters are generally scoriaceous, in a perfect condition, with a depression of the rim usually to the north or east. There are also around the district other volcanic hills, rounded, scoriaceous, more fertile than the crateriform hills, and apparently of an older date.

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4. *On the* Geology *of the* South-eastern part *of* Vancouver Island. By Hilary Bauerman, Esq.

(Transmitted from the Foreign Office to Sir Roderick Murchison, F.R.S., F.G.S., and communicated by him to the Geological Society.)

The following remarks are the results of observations made during the summer and autumn of the year 1858, and are designed to illustrate a series of fossils and rock-specimens collected during the same time from the glacial, tertiary, and cretaceous formations of the island, and from the metamorphic and igneous rocks of Esquimalt and Victoria. The observations have been made at Esquimalt and Nanaimo, and on board H.M.S. "Satellite" in the Gulf of Georgia. The references in the sketch-section annexed are to the map of the S.E. portion of Vancouver Island by J. D. Pemberton, published by Arrowsmith. The beds are described in stratigraphical order, commencing with the lowest.

1. *Metamorphic and Igneous Rocks.*—These are everywhere seen in the neighbourhood of Esquimalt and Victoria, principally occurring in the form of dark-green sandstones and shales, which pass by insensible gradations into serpentine and chlorite-slate. They are very full of small strings and veins of quartz. The harder beds are very much jointed; and it is often difficult to obtain a fresh fracture, owing to their tendency to split into rhomboidal fragments, the surfaces of which are generally much rusted and tarnished from the action of water infiltered through the joints. Several beds of unfossiliferous crystalline limestone are associated with the metamorphic rocks above-described, and are often of considerable thickness. A section in the cliff at the Boundary Commission Barracks exhibits alternations of compact and shaly blue limestone over a thickness of forty feet, the strata being vertical. At another point on the bay, the same series of beds, with greater variation of mineral character, is seen dipping to the northward, at an angle of 50°.

The metamorphic rocks assume a gneissic character to the northward of Esquimalt. On the shores of Thetis Lake, about two miles distant, dark-green sandstones and mica-slates occur, which are penetrated by dykes of largely crystalline greenstone and syenite: the former is made up of large black scales of hornblende and a light-green felspar, and becomes syenitic by the addition of quartz. The effect of these dykes on the rocks penetrated is very apparent, the beds having been completely fused at the points of contact. At the head of Victoria Harbour a dark laminated gneiss, with quartz-veins, is exposed: the direction of the planes of lamination is N. 50° W.,

with a N.E. dip of 35°–45°. Between Victoria and Esquimalt, along the coast, the section shows a series of highly altered rocks, confusedly intermingled with intrusive traps and porphyries. These igneous rocks occur in large dykes, generally splitting and ramifying into small veins near the contact with the rocks into which they are intruded: their general composition is of hard white and green felspar, often mixed up with quartz, forming the rock known as "Petrosilex" or "Hornfels." Other conditions are induced by the addition of crystalline quartz and hornblende, forming quartz-porphyry and syenite. These different varieties of composition are often seen in the same section,—the porphyritic character of the centre of the dyke shading down into the hard, white, flinty trap which fills the small veins thrown out at the sides. These rocks do not in any case appear to be interstratified; the impression they convey is that of being offshoots from a granitic mass immediately below.

The metamorphic character of the sedimentary rocks must be ascribed entirely to chemical action, as no traces of slaty cleavage or other mechanical action are anywhere observable. I have not been able to obtain any evidence of their thickness or probable geological position. I have examined the limestones and softer shales for fossils, but without effect.

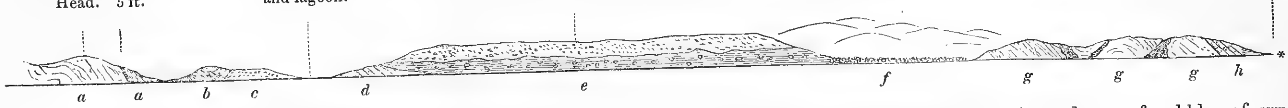
To the westward of Esquimalt, the older rocks are covered by drift-deposits for some miles, and reappear in the form of black cherty sandstones; which are succeeded by a red porphyritic rock, very much altered by infiltration of water: it is very earthy from the partial change of the felspathic base, contains large patches of chlorite, and is feebly magnetic from containing magnetite in minute quantity. In a soft clay-slate adjoining, a large lode occurs, dipping to the N.E. at an angle of 75°; it is about five feet in thickness, but contains no mineral of economic value. The serpentinous rocks in Esquimalt Harbour are in many places coated with a bright-green incrustation resembling a carbonate or silicate of copper; but it proves to be a hydrated protoxide-silicate of iron when closely examined.

To the eastward of Victoria Harbour, the metamorphic and igneous rocks are concealed by the drift. They are seen in Stewart's Island, in the Gulf of Georgia; and in Saturna, the next island to the north, their junction with a conglomerate of large angular fragments is seen, which is succeeded by coarse grits and sandstones of the tertiary period.

2. *Cretaceous Rocks.*—The section at Nanaimo, further to the northward, exposes a series of beds containing cretaceous fossils, underlying the coal-bearing grits. I have had no opportunity of examining these deposits; but as far as I can ascertain from descriptions by Mr. Lord (the naturalist to the expedition), who collected most of the fossils, they consist of dark argillaceous shales, full of casts of a small species of *Inoceramus*, and soft blue marls full of septarian nodules, containing fossils. These consist chiefly of *Ammonites* and *Baculites*; the latter the most abundant. The

Sketch of the Coast-section exposed in Royal Bay, Vancouver Island, in the vicinity of Esquimalt and Victoria Harbours.

General bearing N.E. Length 6 miles.



a. Metamorphic shales and sandstones.
b. Earthy red felspathic porphyry.
c. Black cherty sandstone.
d. Rocks hidden by blue drift-clay (*e*), capped by sands and gravel. Total thickness about 200 feet. The clay contains scratched pebbles and boulders.

f. Shingle-spit (enclosing a salt-lagoon), made up of pebbles of crystalline and slaty rocks, with much jasper.
g. Dark-green serpentinous rocks, with intrusive dykes of hard felspathic trap.
h. Compact blue limestone.

Bearing E.S.E. Length 3 miles.

i. Metamorphic slates and sandstones, much altered and penetrated by veins of granite and porphyry.
j. Dark-green chlorite-slate, covered up by boulder-clay (*k*).

surfaces of the shells are beautifully iridescent. In one instance I found some fish-scales. The localities of the above fossils are two cliffs in the valley of the Nanaimo River, about two miles to the westward of the Hudson's Bay Company's settlement, and are known as Pemberton's and Stewart's Banks. Another locality for similar fossils is at Cormuck's or Comoux Island, twenty-one miles to the N.W. of Nanaimo, where they occur in cement-stone nodules on the sea-shore. The specimens sent from the latter place were obtained by Mr. Dallas, of the Hudson's Bay Company, and Captain Stuart, of the Company's establishment at Nanaimo. The forms obtained from these localities are as follows:—

Fish-scales	Nanaimo River.
Nautilus	" "
Ammonites	Both localities.
Baculites	Very abundant in both localities.
Inoceramus	2 sp. Both localities.
Astarte?	Imperfect casts of interior of shell, Nanaimo River.
Terebratula?	Imperfect casts of interior of shell, Nanaimo River.

3. *Lignite-bearing Tertiaries of Nanaimo.*—These beds immediately succeed the cretaceous rocks; and they are extensively developed over a great extent of country, and form the mass of the islands in the Gulf of Georgia as far south as Saturna Island. Northward they occur at Fort Rupert, the most northerly settlement on Vancouver Island. The sections at Nanaimo exhibit a series of coarse sandstones, grits, and conglomerates, with sandy micaceous flagstones, all of which appear to be unfossiliferous. The sandstones, although intensely hard when freshly exposed, are very concretionary in character, and weather very irregularly. They contain in places large spherical masses of slightly ferruginous sand, twelve to eighteen inches in diameter. Two seams of coal, averaging six to eight feet each in thickness, occur in these beds, and are extensively worked for the supply of the steamers navigating between Victoria and the Frazer River. The coal is a soft black lignite, of a dull earthy fracture, interspersed with small lenticular bands of bright crystalline coal, and resembles some of the duller varieties of coal produced in the South Derbyshire and other central coal-fields in England. In some places it exhibits the peculiar jointed structure (causing it to split into long prisms) which is commonly observed in the brown-coal of Bohemia. A mineral allied to Retinite or Amber is common in the more earthy portions. For economic purposes these beds are very valuable. The coal burns very freely, and yields a light pulverulent ash, giving a very small amount of slag or clinker; its evaporative value is, however, much diminished by its low specific gravity, and by the large quantity of thick black smoke driven off on ignition.

Several partings of green shaly clay, full of the remains of plants, occur in the coal-seams, chiefly impressions of grass-like plants and large leaves. The shales are full of pyrites, and crumble on exposure to the air, rendering it extremely difficult to preserve the fossils. The American geologists are accustomed to assign these deposits to the Miocene period; but as yet no marine fossils have been found

at Nanaimo, so that in this locality there is no sure evidence on which to base such an opinion.

The stratification of the tertiary rocks is very regular: the strike of the beds follows the general direction of the coast of Vancouver Island, from N.W. to S.E. The sections on the western side of the island show steep cliffs, from 150 to 200 feet high,—the regularity of the planes of deposition presenting the appearance of walls of Cyclopean masonry. On the eastern side the beds slope down to the water with a N. to N.E. dip of 10° to 25°. The total thickness of the exposed sections is from 1500 to 2000 feet.

At Bellingham Bay, within the American Territory of Washington, similar coal-bearing sandstones occur, and have been described by Mr. Gibbs (Pacific Railway Reports, vol. i. pp. 472, 473). The eastern extension of these beds, north of the parallel of 49°, I hope to be enabled to examine during the ensuing season.

4. *Pleistocene Deposits.*—The Drift and Boulder-clay are extensively developed over the southern part of Vancouver Island and the opposite coasts of Washington Territory and British Columbia. In the neighbourhood of Esquimalt and Victoria the rocks are deeply scratched and grooved along the shore, and large boulders are scattered irregularly over the surface of the country. Blocks of a white syenitic granite are the largest and most numerous; angular masses, from 60 to 100 tons in weight, are of common occurrence. The other rocks observed as erratics are a black cherty conglomerate, similar to that described as underlying the tertiaries; dark laminated mica-slate, with well-defined garnet-crystals; hornblende-rock and largely crystalline greenstone, and, rarely and in small masses, vesicular obsidian and pitch-stone.

The following section exhibits the general character of the drift at Esquimalt Harbour:—

Black sandy and peaty ground, with broken shells......	2 to 6 feet.
Yellowish sandy clay, with casts of shells (*Cardium* and *Mya*) and a few pebbles and boulders......	6 to 8 feet.
Gravel of scratched pebbles, resting on rock	2 to 3 feet.

The rocks are grooved and scratched at the junction; the direction of the glacial markings is between N.–S. and N.N.W.–S.S.E. In a well-sinking at Esquimalt Barracks, the lower gravel was reached at forty-two feet, after going through a sandy blue clay without shells or boulders. The section in the cliff between Albert Head and Esquimalt is as follows:—

Blue drift-clay, with boulders; junction with rock not seen	70 feet.
Fine sand and gravel, passing upwards into coarse quartzose gravel	100 to 120 feet.

The results of the observations given above show the extension of the lignite-bearing tertiaries to Vancouver Island, and the existence of a system of cretaceous deposits underlying them; but the problem of determining the relations of the latter rocks to the underlying strata will probably remain unsolved for a considerable length of time, owing to the inaccessible nature of the interior of the island.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

November 16, 1859.

Julian Horn Tolmé, Esq., C.E., 20 Queen's Square, Bloomsbury; Thomas Harlin, Esq., M.A., Fellow of St. Peter's College, Cambridge, C.E., 13 Duke Street, Westminster; John Lancaster, Esq., Etruria Hall, Stoke-upon-Trent, Staffordshire; Arnold Rogers, Esq., F.R.C.S.E., 16 Hanover Square, and the Hon. Robert Marsham, the Mote, Maidstone, were elected Fellows.

The following communication was read:—

Supplemental Observations *on the* Order *of the* Ancient Stratified Rocks *of the* North *of* Scotland, *and their associated* Eruptive Rocks. By Sir Roderick I. Murchison, V.P.R.S., F.G.S., Director-General of the Geological Survey of Great Britain, &c.

[See the Map, pl. 12, vol. xv.]

Contents.

Introduction.—Having stated, in my last communication* on this subject, that I proposed to revisit the North of Scotland, in order to

* Quart. Journ. Geol. Soc. vol. xv. p. 359, note.

ascertain still more completely if my general views respecting the older rocks were correct, before I issued a small general geological sketch-map of that region *, I now redeem my promise by offering the following supplemental observations.

As the classification which I had proposed involved very considerable changes in all preconceived ideas relating to the age of many of the so-called primary crystalline rocks of the Highlands, I naturally felt a strong desire that the Local Director of the Geological Survey of Great Britain, who was as much interested as myself in adopting a correct view of the true order of nature, should accompany me.

The observations, therefore, which I now offer, flow from the joint examination of the country by Professor Ramsay and myself,—certain special improvements of the map of Sutherland, and the more correct delineation of outlines of formations, being due to my fellow-labourer, who spared no labour in ascending the highest summits to determine the real relations of the rock-masses.

The whole of this subject having undergone discussion at the late meeting of the British Association, at Aberdeen, subsequently to my last survey, and Professor Nicol having there expressed his dissent from that essential part of the classification whereby I separate the old or fundamental gneiss of the west coast from other flaglike gneissose and micaceous rocks on the east, it has been a source of satisfaction to me that Professor Harkness, who has since visited the west of Sutherland to examine all the critical sections, has arrived at precisely the same conclusions as Prof. Ramsay and myself, as will appear in the sequel.

Fundamental Gneiss.—In addition to the broad distinction formerly pointed out between this massive and intensely crystallized old rock and all the superior and younger rocks of gneissose character, marked attention must be paid to the great discordance in the *strike* or direction of these two rocks.

The dominant strike of the fundamental gneiss of the north-west coast is from N.N.W. to S.S.E., whilst that of the quartz-rocks, limestone, and superior strata, whether micaceous or gneissic, is from N.N.E. to S.S.W., as explained in this diagram (fig. 1). Again, look-

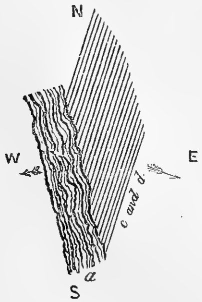
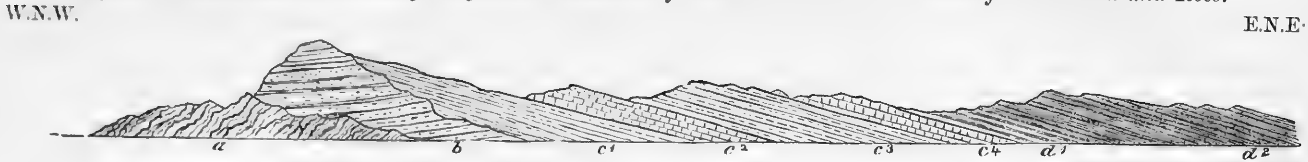


Fig. 1.—*Diagram-plan showing the general relations of the Old or Fundamental Gneiss (a) to the crystalline Lower Silurian rocks (c and d) where the intervening Cambrian rocks (b) are absent.*

a. Old gneiss.
c, d. Quartz-rocks, limestones, mica-schists, and gneissose flagstones.

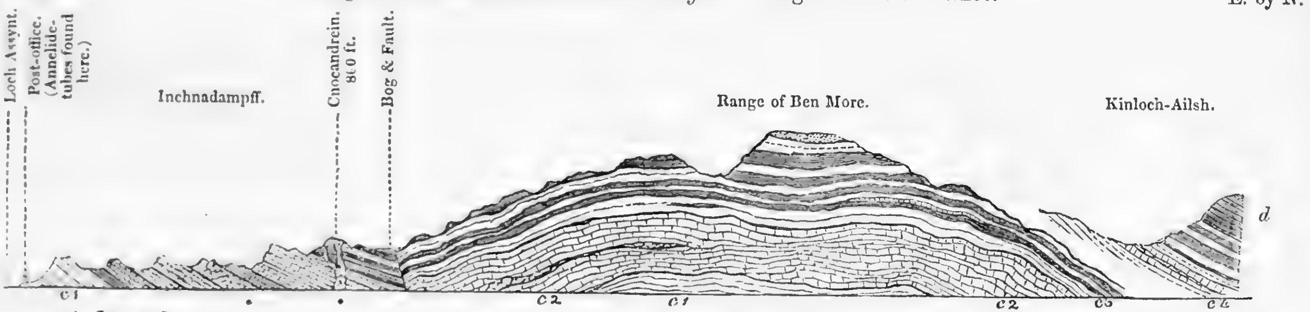
* This map (Pl. 12. of vol. xv.) was published with No. 62 of this Journal.

Fig. 2.—*Diagram-section showing the general Succession of the Rocks in the North-west of Sutherland and Ross.*



a. Fundamental gneiss.
b. Cambrian sandstone and conglomerate.
c^1. Lower Quartz-rock, with *Annelides*.
c^2. Lower Limestone, fossiliferous.
c^3. Upper Quartz-rock; with *Orthoceras* and *Annelides*.
c^4. Upper Limestone.
d^1. Uppermost Quartz-rock passing into micaceous schists.
d^2. Gneissic and micaceous flagstones, occasionally talcose and chloritic.

Fig. 3.—*Generalized Section in Assynt.* Length about six miles.



c^1. Lower Quartz-rock.
c^2. Lower Limestone, with intercalated igneous rock.
c^3. Upper Quartz-rock.
c^4. Upper Limestone of Loch Ailsh, with intercalated igneous rock.
d. Quartzose and micaceous flagstones.
* Igneous Rocks.

ing at the prevalent inclination of this older gneiss, we find that it is usually to the west, whilst the overlying rocks in question, extending over enormous areas, dip everywhere to the east (fig. 2). Passing over the red and chocolate-coloured Cambrian sandstone (*b*), we find that the first succeeding quartz-rocks and limestone (*c*), as well as the next overlying micaceous schists and gneissose strata (*d*), have a prevalent N.N.E. and S.S.W. strike (deviating, it is true, to the N. and S., but never assuming the direction of the old or fundamental gneiss), and with a determined prevalent dip to the east. Looking to this fact, and to the clear order of superposition (as expressed in the general section, fig. 2), and to a decided mineral distinction between the true bottom-rock (*a*) and all the strata which overlie them to the east, the hypothetical suggestion thrown out by Prof. Nicol at the meeting of the British Association at Aberdeen, that the eastern or gneissose and micaceous rock may be simply the older gneiss exposed by denudations or brought up by faults, cannot, in my opinion, be entertained. This point will presently be illustrated by fresh sections, when, having treated of the fossiliferous Lower Silurian (*c*), we come to those crystalline mica-schists and quasi-gneissose strata (*d*) which repose upon them.

In the mean time I may state that, after carefully examining the fundamental gneiss from Loch Inver to Durness, and then immediately contrasting it with the upper micaceous and gneissose strata, Prof. Ramsay and myself were quite as much struck with the great lithological dissimilarity of structure and the different direction of the two sets of rocks, as we are prepared to prove, by distinct natural evidences in the field, that they are widely separated from each other by an unquestionable order of superposition, and can never be merged under the same colour and represented by the same letter, as they have been in all previous geological maps of Scotland. Let any geologist traverse, for example, the Kyles of Strom, on the west coast of Sutherland, and there examine all the highly crystalline, ponderous, grey gneiss, extending to Scourie and Loch Stack, or view the grand development of the same rock, with huge granitic intrusions, on the shores of Loch Laxford, where it forms the base of the Fionavin range of quartz-rock, and its extension into Ben Spionnach, and then contrast that subjacent rock with the micaceous flaggy strata lying to the east of Assynt, Loch More, and Loch Eriboll, and he will, I doubt not, arrive at the conclusion maintained in my previous memoirs.

Cambrian Rocks of the North-west Coast.—I have no modification to make in what has been already stated respecting these rocks, but would merely enlarge upon certain details respecting them. Thus, in referring to the pictorial frontispiece at the head of the last edition of 'Siluria,' the reader must understand that the chocolate-coloured horizontal sandstone extends over a larger area under the peak of Queenaig than is there represented.

In regard to the base of the Cambrian or Longmynd sandstone, as resting on the fundamental gneiss, it is well also to point the special attention of travelling geologists to the junctions near the Gwalin

Inn, or between Rhiconich and Durness. There, these bottom-beds, in the form of pebbly red conglomerate, quite identical with that on the summit of Cape Wrath*, are well exposed in nearly horizontal beds on the banks of the rivulet which descends from the high plateau two miles south of the Gwalin, and again to the north of that inn on the sides of the high road. Here, as at Cape Wrath and elsewhere, all the pebbles consist of the fundamental gneiss or of the associated red granite.

In their simple uniform composition, these very ancient sandstones and red conglomerates differ essentially from the much younger Old Red Sandstone which is exposed on the East Coast, where the pebbles and ingredients change, as before shown, with those older rocks respectively on which they repose, and out of the materials of which they are composed.

These Cambrian rocks, which are so nobly exposed in mountain-masses along the West Coast, are confined (the reader will recollect) to that western meridian, and nowhere advance more than a few miles eastward into the interior of the mainland; but, as they occur as coarse conglomerates on the eastern shore of the Island of Lewis (where they also rest on a vast breadth of the fundamental gneiss), they must certainly at one period have been much more extensively distributed. The district, on the mainland, where these Cambrian strata can be most easily studied is in the mountain of Queenaig in Assynt, particularly along the fine escarpment between its summit and the Kyle of Strom, where they repose in striking unconformability upon the old gneiss, and are covered, also unconformably, by the quartz-rocks of Lower Silurian age.

The phenomenon relating to these Cambrian sandstones which may well strike the geologist as he passes over the summits of Suilven and Queenaig, is that these very ancient rocks, on which unquestionably the Lower Silurian rocks repose, should be simply sandstones and grits which have undergone much less change than the sandstone which lies upon them,—the latter having been metamorphosed into quartz-rock. However difficult it may be to account for this fact, it is at all events *most instructive as regards the origin and succession of life in the crust of the earth*, and sustains my view of a beginning. For here (and I have applied the same argument before to the Cambrian sandstones of the Longmynd, which certainly underlie the quartz-rock of the Stiper Stones†) the older of the two rocks in Scotland has offered no trace of fossils, whilst the more crystallized structure above exhibits unmistakeable signs of former living things.

Silurian Quartz-rocks and Limestones.—The excursion of last summer reassured me that I had not erred in stating that the great band of limestone of Assynt, Durness, &c., was fairly intercalated in quartz-rock, both inferior and superior; that, besides the chief band, there was another and superior limestone overlying the upper quartz-rock; and further, that all these were conformably superposed by

* See former description of these pebble-beds, Quart. Journ. Geol. Soc. vol. xv. p. 362.

† See 'Silurian System,' p. 284, and 'Siluria,' 2nd edit. p. 39.

flaglike micaceous rocks, which in parts have the same constituent particles as gneiss.

Let us first consider a few additional data, explanatory of this view, as derived from the last examination of the tracts of Assynt, Durness, Eriboll, &c.

Assynt.—New sections are now offered, to show how completely the chief limestones lie between lower and upper quartz-rocks. Another section is added to demonstrate how all this quartzose series is followed by a second or superior limestone, which, in its turn, is overlain by micaceous and gneissose schists, &c. The first of these (fig. 3, p. 217) may be seen by any one who walks from near the post-office of Assynt, on the west, across the ridges of limestone, to the hills on the east-by-north.

The lower quartz-rock, which slopes down from the edges of the Cambrian rock of the Canisp, presents its uppermost band only on the side of the Loch, and is followed by the passage-beds with Fucoids and Annelides formerly described. To these succeed light-grey limestones, of concretionary structure, which, on approaching an intercalated band of syenitic greenstone, become dark-coloured and fetid under the hammer. This syenitic greenstone, which is best exposed at a turn of the road about a mile west of Inchnadampff, is from 40 to 50 feet thick, and as regularly bedded as the limestone below and above it, though, on examination, it is seen to be a true igneous rock, containing crystals of hornblende, with felspar and quartz. In other parts it weathers into a softer mass, and might there be taken for a volcanic ash.

The limestone above this igneous rock is, indeed, more altered than that which lies beneath it, and is in parts a crystalline marble, which, many years ago, a speculator began to work for ornamental purposes. These limestones and marbles, with their associated igneous rocks, can be traced at intervals from $1\frac{1}{2}$ mile to the west of Inchnadampff, along the escarpment of Stromchrubie, to near Elphin, altogether a distance of about eight miles.

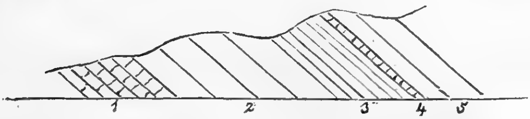
Ascending from these dark limestones and marbles, dipping from 25° to 30° to the east and east-by-north, you pass over successive ledges of partially brecciated and scaly-fractured, lighter-coloured layers, and next over a succession of lighter-coloured limestone, containing, however, one dark band. On rising towards the hill of Cnoc-an-drein, a steep scarp presents a most systematic ascending section, the strata in which, rising gradually in inclination to about 40°, pass up into, and are conformably surmounted by, the upper quartz-rock. But, whether the inclination rises to 40° or diminishes to 25°, as at the east end of the ridge above the Manse of Ichnadampff, the limestone is everywhere symmetrically overlain by the upper quartz-rock. This upper quartz differs from the lower only in being less grey and white, and in having more of a pinkish colour; but it resembles the older rock in containing Annelide-tubes, which often traverse several layers of the rock*. The accompanying

* See woodcut, Quart. Journ. Geol. Soc. vol. xv. p. 368.

section, fig. 4, drawn and sent to me by Prof. Harkness, confirms distinctly my view of the limestone being merely a subordinate part

Fig. 4.—*Section South-west of Cnoc-an-drein. Inchnadampff.*

W.S.W. E.N.E.



1. Lower Limestone, cherty.
2. Thick-bedded white quartz-rock.
3. Purple quartz-rock, with *Serpulites.*
4. Thin limestone.
5. Thick-bedded quartz-rock.

of the quartz-rock series. He has detected one thin course of limestone at the spot indicated, above the Manse of Inchnadampff.

By walking along the summit of Cnoc-an-drein, and about 150 feet above the limestone, I observed in one spot a small portion of apparently intrusive felspar-rock; but it had no persistence right or left, and did not affect the dip of the strata, any more than the syenitic greenstone in the heart of the limestone. Continuing this section, however, the upper quartz-rock is soon seen to be affected by a down-cast fault on the east; though the strata, rising with a reversed inclination, are seen, as in fig. 3, to be the same as those to the west of the fault, as they also exhibit a pink tint*, and contain similar Annelide-tubes†. Thence the upper quartz, which is a continuation of the chief mass of the adjacent lofty mountains, including Ben More of Assynt, undulates for great distances to the east-by-north, and finally in Kinloch-Ailsh dips under another limestone covered by mica-schists and gneissose strata, of which hereafter.

I have first dwelt on the parts of this section near Inchnadampff to show, first, that igneous rocks included in the heart of the limestone and overlying quartz-rock do not operate as lines of separation; and secondly, that the first notable fault which can be detected is not between the limestone and the overlying strata, but is actually within the upper quartz itself‡. It will presently be shown that such faults are very numerous, and are quite irrespective of the age of the deposits. Several of these were laid down,

* This distinction of colour is purely local; for the upper quartz also weathers white over large areas.

† Since the memoir was read, more extended and more perfect evidences of the existence of these large Sea-worms or Annelides have been found in the hard quartz-rocks of the lofty mountain of Fionavin (porous quartz-rock), by the sons of Mr. Clark of Eriboll. These burrows, many inches deep, and as large as a man's finger, resemble closely those made by the great lob- or lug-worm of the fishermen (*Arenicola piscatorum*), and, by the arrangement of the once sandy material, afford evidence of the upward and downward movements of the ancient worm. They are for the most part in pairs, like those Annelides so well described by Mr. Binney from the paving-flags near Manchester.

‡ See Professor Nicol's statement, that a great fault occurs between the limestone and the upper quartz: and his diagram, bringing up the older quartz on the dip-side of the limestone (Quart. Journ. Geol. Soc. vol. xiii. p. 23).

after laborious walks, by Professor Ramsay on the Duke of Sutherland's map, which I submit to the inspection of the Society; but I would here observe that no attempt can be made to insert all these faults with accuracy until accurate Ordnance Survey Maps of the region shall have been completed.

As bearing on the resemblance of these quartzose and calcareous rocks to their equivalents in America, I may mention that a recent comparison of several of the American so-called fucoids has enabled Mr. Salter satisfactorily to refer them in many cases to the vertical tubes, or, rather, filled-up burrows of large marine worms. He particularly cites the *Phytopsis tubulosus* of the "Calciferous Sand-rock" of the American geologists; the celebrated "Birds' Eyes" (*Phytopsis cellulosus*) of the "Birds'-eye Limestone," and the *Buthotrephis succulens* of the Trenton group, as being of this nature. The part played by Annelides in the older palæozoic epoch was, we thus know, very conspicuous.

Let us now pass to the other parts of the section, fig. 3, which shows the principal or lower limestone resting upon the lower quartz-rock, and succeeded by the vast overlying masses of upper quartz-rock, constituting the lofty range of Ben More in Assynt, the summit of which rises to 3235 feet above the sea.

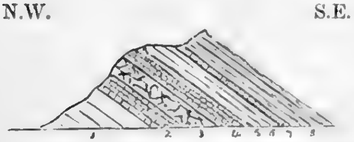
Section of Ben More of Assynt.—Viewed on the great scale, as just described, the limestone which lies to the west of the church and village of Assynt occupies a thickness of about 700 or 800 feet, whence it spreads out to the east and south over the extensive upland plateau above Stromchrubie, where, however, many quartzose strata prevail in it. As soon as the explorer has passed the small inland lake (Maoloch-corry), well known to sportsmen by containing the "Gillaroo trout," this limestone, so thick and broadly expanded on Loch Assynt, has already diminished to a thin band, of less pure character, which, as you climb to the Bealloch, or pass under Ben More, is seen to dip beneath the stupendous mass of upper quartz-rock which constitutes the Coniveall, or culminating point of the range. Nowhere is the contrast between the lower and upper quartz-rock more strongly marked; for, whilst the former is well exposed as a grey rock (c^1, fig. 2), which weathers white, on the northern flanks of Canisp, where it descends from that mountain to dip under the limestone of Stromchrubie, the upper quartz is presented in the form of a lofty escarpment, the beds of which in their outcrop distinctly overlie the limestone. Here again the pinkish or roseate colour of the overlying mass is strikingly contrasted with the lower quartz, immense quantities of the higher rock having fallen down upon the edge of the calcareous zone. Whilst I ascended to this pass, where the order is so clearly recognized, Prof. Ramsay completed the proofs by climbing to the summit of the chain, all of which he still found, at a height of 3235 feet, to be composed of quartz-rock, in parts pebbly*. Wrapping round the sinuosities of the older rocks, these great masses of upper quartz-rock, whether

* These upper pebbly beds are locally called "Button-stones."

dipping slightly to the north of east, as in Ben More of Assynt and adjacent mountains, or E. and E.S.E. in a more southerly district, are invariably surmounted by younger micaceous and gneissose strata. In my communication of last year I stated that the quartz-rocks were also overlain by a second zone of limestone in the country to the east of Assynt; and the fact has this year been corroborated by Professors Ramsay and Harkness. With the addition of some material data, I am now enabled to reaffirm, not only that this second limestone is superior to all the quartzo-calcareous strata, but is, as I showed, *conformably* surmounted by those upper micaceous, chloritic, gneissose, flaggy strata, the overlying position of which is thus completely established. Professor Ramsay* not merely observed this upper limestone where I had previously noticed it, but rendered the case conclusive by tracing the rock from Cnoc-chaorie, on the high road to Loch Ailsh, to the north, until he saw it following the sinuous outline of the subjacent quartz-rocks. In this form it is always seen dipping away conformably to the east or south and north of east, according to the folds of the inferior strata which rise into the lofty mountains of Ben More†. From Kinloch-Ailsh this upper limestone sweeps round to the east and north of the mountain of Ben More, and extends up the valley of the Cashly to the east side of the Stack of Glencoul. Lithologically this limestone differs from that of Assynt in being of a lighter colour and having somewhat of a magnesian character; and though no fossils have as yet been found in it, I do not despair that such may still be detected.

The position of this upper limestone is further important, in showing that, whilst it is conformable for many miles to the subjacent quartz-rock, it is overlain in like conformity by those dark-coloured micaceous and chloritic schists and flagstones to which I called attention last year as dipping to the E.S.E. upon the banks of the River Oykel. These strata, becoming more gneissose in parts, and particularly in their higher members towards Oykel Bridge, are those which Prof. Nicol does not yet admit to be younger than the quartzo-calcareous series. Strengthened, however, in my opinion by the examination of Prof. Ramsay, and also by Prof. Harkness's ‡ subsequent examination, I again assert that in this line of section,

Fig. 5.—*Section East of Alt Ellag.*



1. Quartz-rock.
2. Limestone.
3. Hornstone-porphyry.
4. Limestone.
5. Gneissose quartz-rock.
6. Quartz-rock.
7. Gneissose limestone.
8. Upper flaggy gneiss.

Dip. 45° S.E.

* Being unwell on this occasion, I begged Prof. Ramsay to make this examination by himself; and as Prof. Harkness has since arrived at a similar conclusion, my former inferences are thus supported by two independent observers.

† See the east end of fig. 3.

‡ Prof. Harkness minutely describes the junction of the upper quartz-rock and limestone with the so-called "superior gneiss;" and I thank him for the pains he has taken to demonstrate the true order of the rocks to the east of Alt Ellag (as shown in fig. 5):

and for several miles across the strata, as in other localities to which I shall afterwards call attention, the order of succession is complete and unbroken, whether there be or be not any rock of igneous origin between the upper limestone and the dark micaceous schists and gneissose flags. Yet these last are coloured in all maps as if they were of the same age as the fundamental gneiss, though they are separated from that rock by enormously thick deposits of Silurian and Cambrian age, and have a strike entirely discordant to that of the older gneiss. (See the sketch-map Pl. XII. in Vol. xv.)

My present aim therefore is, in the first instance, to select, within the tract forming the north-western portion of Sutherland, those districts where in breadths of a few miles (across the strike) the sedimentary strata representing the Lower Silurian quartz-rocks and limestones are seen to pass up into, and to be conformably succeeded by, other overlying crystalline rocks, often highly micaceous, sometimes quartzose, and occasionally gneissose, without any general break, albeit bands of igneous rock occasionally occur near the lines of junction, as they do indeed at intervals throughout the whole of the ascending series.

The greater masses of the igneous rocks which either break through the deposits or are associated with certain strata at different and very various horizons will be spoken of hereafter.

Transverse Section from the west end of Loch Stack and the mountains of Ben Stack and Ben Strome, to the east end, or head, of Loch More.—Having described a general section in Assynt from the fundamental gneiss, through Cambrian and Lower Silurian rocks, to overlying gneissose and micaceous flagstones, I now call attention to natural sections, where, the Cambrian rocks being absent, the lower gneiss is at once unconformably surmounted by Lower Silurian rocks similar to those of Assynt, which, from the lower quartz-rock upwards through limestones to the overlying quartzose, micaceous, and gneissic flagstones, also form a complete and continuous series.

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1. Quartz-rock; a portion of that which extends far to the west. 2. Limestone. 3. A band of felspar-rock, which in parts has the character of hornstone-porphyry. 4. Hard dark-grey limestone, similar to that below the igneous rock. 5. Quartz-rock, with gneissic laminæ, particularly near its base. 6. Thin course of limestone, 6 inches only, splitting into gneissic laminæ. 7. The base of the chief mass of overlying "gneiss," which occupies so large a surface on the banks of the Oykel.

In describing this section, which so clearly proves the transition from the underlying quartz-rock and limestone into the so-called gneiss, Prof. Harkness well observes that the thin band of intercalated porphyry in no way disturbs the parallel arrangement of the sedimentary rocks. It has either, he says, insinuated itself between the layer of limestone, or has been ejected anteriorly to the deposition of the upper limestone. "From the lower portion of the quartz-rock," he adds, "to the uppermost gneiss (both inclusive), there is a uniform *south-easterly* dip of about 45°; and the whole are seen distinctly passing under the flaggy gneiss. The same mode of association can be traced to Loch Ailsh and the River Cashly, for a distance of many miles, and is well seen at both ends of the Loch, where the limestones and their accompanying strata present themselves in well-developed masses."

The lower or fundamental gneiss, near the coast of Scourie and Loch Laxford, occupies low hills, which have been much worn down by glacial action and drift. These, as they range eastwards up to the summit of the mountain called Ben Stack, constitute the base or support of the overlying white quartz-rocks of Arkle and Fionaven.

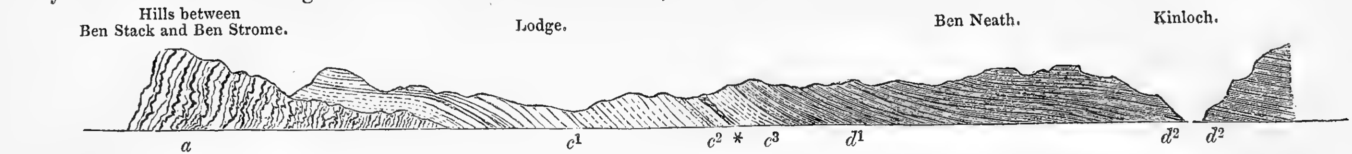
Nowhere in the North-west Highlands are grander geological features seen than where these quartz-rocks, weathering white in the escarpments of Arkle and Fionaven, repose upon the massive old grey gneiss, with its numerous intrusions of red granite. Passing to the east from either of these mountains, the observer meets first with a limestone covering the lower quartz-rock, and next with superimposed masses of quartzose, micaceous, flag-like strata. I specially call attention to a section from Ben Stack, at the lower end of Loch Stack, to the head of Loch More, because no traveller will have any difficulty in examining it, since the high road from Scourie to Lairg runs parallel to it. (See fig. 6, p. 226.)

The old or massive gneiss, trending from S.S.E. to N.N.W., is well exposed on the sides of the high road on the south bank of Loch Stach, where, dipping 35° west of south, it has been much cut into, and where huge granitic intrusions are finely displayed. He who climbs to the summits of Ben Stack will see that this old gneiss is covered by a thin pebbly conglomerate, which dips at a low angle to the S.E. and there forms the base of the lowest of the Silurian quartz-rocks. The latter rock, though much denuded, and not nearly so well exposed as in Arkle and Fionaven, occupies considerable dimensions in the hills north of the upper end of Loch Stack (Ben Strome), whence it slopes down to the western end of Loch More with an easterly dip. A little to the east of a shooting-lodge on Loch More, the limestone succeeds, as expressed in this section, fig. 6. Here, as at the head of Glencoul, and all the tract extending to the S.W. between Loch More and Assynt, and again to the N.E. between Loch More and Loch Eriboll, the limestone is diminished to a thin course. In this respect the limestone bears the same irregular proportions to the quartzose rock in which it is intercalated as the Lower Silurian limestones of Wales do to their associated slaty and siliceous rocks. In Wales, as in Sutherland, the calcareous matter is every here and there of considerable dimensions, and at other places it dwindles away to mere threads, and is often entirely lost.

In examining the limestone upon the steep banks of a mountain-torrent which flows into the south side of Loch More, Prof. Ramsay and myself observed, it is true, an intercalated igneous rock; but, as we also saw that the calcareous band was followed conformably, as in Assynt, by an overlying quartzose rock, we remained of opinion that here, as elsewhere, the occurrence of a felspathic or porphyritic rock, whether above or below the limestone, did not interfere with the general order of succession*.

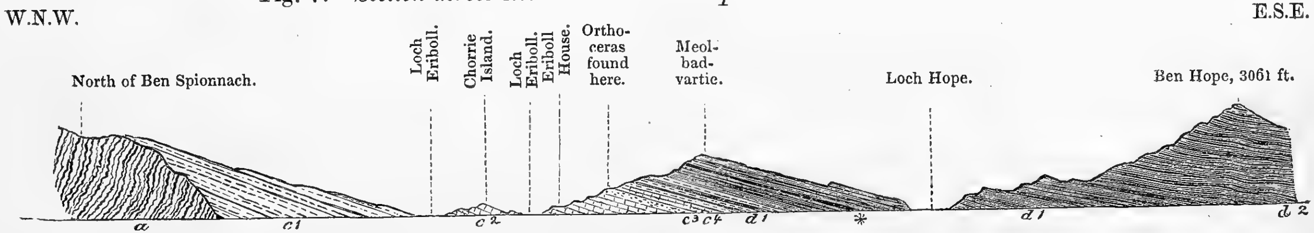
* Prof. Nicol states that this igneous rock acquires larger dimensions higher up in the mountain: and I do not doubt the fact, though neither Prof. Ramsay

Fig. 6.—*Section on the South Bank of Loch More.* Distance about six miles.



a. Fundamental Gneiss.
c^1. Lower Quartz-rock.
c^2. Limestone.
c^3. Upper Quartz-rock.
d^1. Quartzose and micaceous flags.
d^2. Micaceous and gneissose flagstones.
* Igneous rock.

Fig. 7.—*Section across Lochs Eriboll and Hope.* Distance about ten miles.



a. Fundamental gneiss.
c^1. Lower Quartz-rock.
c^2. Lower Limestone.
c^3, Upper Quartz-rock.
c^4. Upper Limestone.
d^1. Micaceous and quartzose flagstones.
d^2. Micaceous and gneissose flagstones.
*. Intercalated igneous rock.

Now the overlying quartzose rock of Loch More passes gradually upwards into a micaceous flagstone, which extends to the head of the loch at Kinloch. This micaceo-quartzose flagstone (the wide-spread "gneiss" of the maps), which, when fractured, is of grey colour and very finely laminated, is essentially different in structure, strike, and dip—in short, in every respect—from the old or fundamental gneiss of Loch Stack, distant only five miles,—the latter, as before said, dipping to the W.S.W., whilst these micaceous flagstones overlying the limestone dip east. When, therefore, we see in this very limited distance, that, besides the manifest lithological distinction between the massive lower and highly crystalline granitic gneiss and the superior flagstones, these two rocks have utterly discordant strikes and dips, and that the Silurian quartz-rocks and limestone are regularly interposed between them (the uppermost flaggy strata following conformably the quartz-rock and limestone), the conclusion is irresistible.

Whilst such is clearly the general ascending succession, it is at the same time to be stated that the stratified rocks of this tract, like those of most other Highland districts, have been subjected to many fractures and faults. Thus, Loch More and Loch Stack are sheets of water that occupy the line of great faults transversal to the strike. This phenomenon is clearly marked by the place occupied by the limestone on the opposite banks of Loch More. On the north bank, where in 1858 I traced the limestone through the moss and moor, the rock is slightly inclined only; but on the south bank, as in the section, fig. 6, it is very highly inclined. But these transverse dislocations serve only still more to support the conclusions arrived at, since, notwithstanding their occurrence, the same order of succession is seen on both sides of this broad loch which traverses all the succeeding strata which lie upon the fundamental gneiss.

Additional observations on the tract of Durness.—This tract of Lower Silurian limestone (*c*), so celebrated for its fossil contents, has been subjected to so many dislocations, that in one line of traverse only, or that in which my former section* passed, can it be viewed as unbroken. Though the lower quartz-rock, which dips away from the Cambrian rock of Scrishven, and occupies the western side only of the Kyles of Durness, absolutely plunges under the limestone, and is again brought up by a reversed dip against the older gneiss of Ben Keannabin, no other transverse section thus represents a trough. On the contrary, the limestone is thrown abruptly into contact with the old gneiss of Ben Keannabin and Ben Spionnach on the north-east, and constitutes a narrow wedge-shaped mass between that great fault and an equally large one, which truncates it against the old gneiss on the west side of the upper end of the Kyle of Durness.

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nor myself attach importance to it. I shall afterwards show that in other places the protrusion of vast masses of such igneous rock does not break up or interfere with the continuous superposition of the sedimentary strata.

* Quart. Journ. Geol. Soc. vol. xv. p. 364.

Nor is the ascending order above the limestone to be seen in the parish of Durness without the intervention of a great fault. For, though the former section (fig. 6, p. 371, vol. xv.) is correct in showing that the flaglike rocks constituting the cliffs on which the Old Bishop's Castle is placed are superior to the limestone, I did not then show that the valley which separates the two rocks was the line of a great dislocation. In truth, I had not sufficiently examined, as I have now done, the rock of the bold northern promontory of the Farrid or Far-out Head.

That promontory was erroneously referred to the old gneiss in my former memoir, on conclusions drawn from a hasty visit of my friend Mr. Peach, who brought to me specimens from one part of the headland which had a gneissose aspect. Detailed examination, in company with Prof. Ramsay, has, however, convinced me that the whole of this headland, from its northern extremity to the Bishop's Castle, a distance of several miles, is composed of the overlying flaggy quartzo-micaceous series. Owing to the great fault which trends along the Bay of Balnakeale, the quartzose beds, which in other places unite the limestones with the overlying series, are not visible,—the lowest strata apparent on the sands of Balnakeale being hard, dark-grey, flaggy, micaceous sandstones, in parts having a flat-bedded and somewhat gneissic aspect. These graduate upwards into beds which are less micaceous, and become in parts white and siliceous, with a slight greenish tinge. The whole of these beds dip to the east at angles from 15° to 20°. From their utility, the white flagstones have been quarried to some extent, and here and there exhibit very broad masses, one of which, called "the good wife's flag," projects seawards for several yards from the lofty summit of one of the headlands. These flagstones closely resemble those of Melniss on the west side of Loch Tongue, to which I last year called attention; and I now repeat that no geologist who ever looked at them could connect them with the old or fundamental gneiss of the West Coast.

Their relative position at Melniss, where they overlie a vast mass of the micaceous quartzose rocks, as well as the quartzose rocks and limestone of Eriboll, was dwelt upon last year.

The geologist who wishes to convince himself of the manifest distinction between these upper flaggy rocks and that fundamental gneiss which is seen on the west side of the Kyle of Durness, or that which extends from the hill of Keannabin on the east to the headland of Rispond, will at once see the distinction by passing from thence to the promontory of the Farrid Head, and specially by examining its eastern cliffs.

Although this broad distinction is obvious, it is no easy matter to define with accuracy all the dislocations within the limited Durness basin until the country be well mapped. My note-books contain many details showing the curvatures, metamorphism, and breaks in the strata; and in no part of the district are these phenomena more striking than in the limited tract of Sangoe Bay and its northern and southern extremities below Durine Inn. There hard

metamorphosed rocks are thrust about in dire confusion, connected apparently with the great fault of Balnakeale Bay and associated with serpentine. Prof. Harkness thought that he could here also trace north and south faults.

Now, whether or not the arrangement of the strata be found to be more or less in accordance with his view, my object is gained by simply showing that, occupying a highly broken trough, the Durness limestone is really proved to rest upon the lower quartz-rock, and to be flanked, and indeed overlain, by the upper series of quartzose and gneissose rocks. The clear order of succession is, however, so admirably seen on the shores of Loch Eriboll, that we may now review the natural sections which are there exhibited.

Section across Loch Eriboll to the adjacent country on the East.—Having been enabled, through the hospitality of my friend Mr. Alex. Clark, of Eriboll House, to re-examine in detail the transverse section across the escarpment where Prof. Sedgwick and myself observed (1827) the clear superposition of the micaceous flagstones, chloritic schists, and younger gneissic strata to the limestones of Loch Eriboll, I have now the satisfaction of being able to produce some important additional details, and to confirm the accuracy of my general conclusions by the testimony of my companion Prof. Ramsay, and also of Prof. Harkness, who has since visited these spots.

In order, however, to convey to the reader a clear view of the whole subject, I will call his attention, as in Assynt and at Loch More, to the ascending order, as exhibited in a transverse section of about ten miles in length (see fig. 7, p. 226).

The fundamental or massive gneiss, which occupies the escarpment of Ben Spionnach, and is well exhibited on the sides of a little loch, and in the sides of the torrent (Alt-ach-na-cailk) running down to the Bridge of Grudie, is unconformably surmounted on its summit by the bottom-beds of the lower quartz-rock, which, though not so coarse as on the summit of Ben Stack, are still pebbly grits, the finer beds of which might serve as millstones. These, covered by a considerable thickness of fine-grained quartz-rock, dip away to the E. and E.S.E. into Loch Eriboll, the western bank of which is almost entirely composed of them. The overlying limestone is seen in the Island of Chorrie, reappearing in force on the mainland at and above the house of Mr. Clark, in ascending from which, to the summits of the hills on the east, the clear order of superposition is exhibited which is given in the preceding section (fig. 7), and which may be seen over a breadth of two or three miles, particularly in the escarpments and on the summits which lie to the north of the road ascending from Eriboll House to Altnaharrow.

In comparing this section with that in Quart. Journ. Geol. Soc. vol. xv. p. 383, of the same tract, it will be observed that, whilst the general succession is identical, some important details are now added.

Thus, the limestone which rises from the loch, and forms a succession of terraces, is separated from an upper limestone of much less thickness by a zone of quartz-rock, about 500 feet in thickness,

which afforded the Orthoceratite presented to me by Mr. Clark and now laid before the Society.

Mr. Salter says that this large Cephalopod resembles the *Orthoceras* (*Cameroceras*) *Brongniartii* *; and he thus describes the specimen: "This fragment (from the upper quartz-rock of Eriboll, collected by Mr. Clark), imperfect as it is, shows enough to distinguish it specifically from the large-tubed *Orthoceras duplex* of the Scandinavian rocks, inasmuch as the ridges on the great lateral siphuncle (lines of junction with the septa) are closer and less oblique. The septa themselves are very convex.

"The comparison with American species cannot well be made, for want of more complete drawings of the latter. But the Irish fossil identified by Portlock with an American species (*O. Brongniartii*, Troost?) seems to be the same as our fossil. In neither is the siphuncle strictly lateral; and hence this species tends to connect *Cameroceras* with the more ordinary forms of the genus."

The occurrence of this fossil in the quartz-rock leads to the belief that, when the limestones of Loch Eriboll are searched with the same assiduity as was applied by Mr. Peach to their equivalents in Durness, other fossils will also be detected in them.

The upper limestone, which is thin, and not persistent for any considerable distance on the strike, is seen to graduate upwards under Meol-bad-vartie into quartzose, felspathic, micaceous, thin-bedded strata, which in parts assume a greenish tinge, and so pass upwards into that series of micaceous, felspathic, and quartzose flagstones which in parts have gneissic characters.

All these overlying strata repose conformably at slight angles of inclination on the whole of the quartzites with limestone, and without any break or separation.

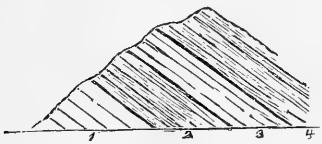


Fig. 8.—*Section at Tordleadh.*

1. Quartz-rock.
2. Gneissose flagstone.
3. Quartz-rock.
4. Gneissose flagstone.

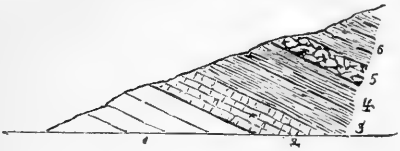
Dip. 35° S.E.

Prof. Harkness has transmitted to me a section (fig. 9) of the alternation of the quartz-rock and upper gneiss at a spot called Tord-leadh, or the Green Knoll, to the N.E. of the House of Eriboll, which completely sustains this view of the gradual and conformable transition, and shows that there are considerable spaces where no intercalated igneous rock is visible. It is true that Prof. Harkness has observed what Prof. Ramsay and myself failed to detect (as well we might in a lofty mountain-escarpment),—viz. the existence of 3 feet of interstratified igneous felstone, represented in fig. 9. It is, however, to be observed, that not only does this felstone not interfere with the regular sequence and conformable overlying succession, but, instead of lying

* Portlock, Geol. Rep. pl. 28. f. 4.

between the upper limestone and the overlying so-called "gneiss" or mica-schist, it is interstratified with the latter rock, and, being

Fig. 9.—*Section of the Junction of the Quartz-rock and Gneissose beds above Eriboll House.*



1. Quartz-rock.
2. Upper limestone.
3. Gneissose quartz-rock.
4. Gneissic strata.
5. Felstone (granitic).
6. Gneissic and micaceous schists.

a part of the overlying deposit, cannot be cited in any sense as forming a barrier between the quartzose calcareous group and the superior strata.

In the sequel it will be seen that, in following these beds on their strike to Whiten Head, where the whole of the interstratified limestone thins out, the granitic felstones really perform the part of intrusive rocks which have been injected into the overlying schists and dark green chloritic flagstones, although the regular order of superposition of the latter is still undisturbed.

In short, the observer who walks along the summits of the escarpments above the House of Eriboll will see that all the flaggy, micaceous or quartzo-gneissose series, with its siliceous flagstones, clearly surmounts all the quartzo-calcareous series, and dips away gradually to the E.S.E. Passing under the base of the lofty mountain of Ben Hope (fig. 7), these rocks constitute indisputably a higher member of the Lower Silurian series than the quartz-rocks and limestones of Durness and Eriboll. These sections, I affirm, are as clearly demonstrative of an ascending order as any which ever fell under my notice or that of Professors Ramsay and Harkness; and every traveller who proceeds from Eriboll to Altnaharrow is invited to witness the proofs of this order without even quitting the sides of the high road.

It is needless to ask such observer to contrast the old gneiss (*a*) of Ben Spionnach or Rispond, distant a few miles only, which dips to the west-south-west, with any of these very different quartzose, micaceous, or gneissose flagstones (*d*) on the east side of Loch Eriboll, which are inclined to the S.E.; because, as the latter exhibit no reversal of the easterly dip, it is physically impossible that the superposed strata can be equivalents of the rock which lies beneath all the quartzose series (*c*) and dips to the west. (See section, fig. 7, p. 226; and map, Q. J. G. S. vol. xv. pl. 12.)

In regard to the mineral distinctions and demarcations which have been drawn in the geological map of Macculloch*, and in all succeeding maps, between that which has been called "gneiss" and certain associated micaceous, chloritic, talcose, and argillaceous

* Macculloch's map was constructed, chiefly from his own materials, after his death.

schists, I simply view the latter as accidental and lithological variations which have no true geological bearing. Thus, in the north of Sutherland and in the clear sections to the east of Loch Eriboll, the mere occurrence of more mica in some of the beds than in others affords no reason for the insertion of a great mass of mica-schist, which, by the unconformity of delineation as marked on the maps, is made in one part of the tract to succeed to the quartz-rock, and in another to an intercalated mass of "gneiss." The fact, on the contrary, is, that both the so-called "gneiss" and the mica-schist are part and parcel of the same great band of overlying strata, the varying mineral members of which have a similar dip and strike. In other words, the one of these flagstones is simply a continuation of the other; and, whether more or less micaceous, felspathic, or quartzose, they all distinctly overlie the purely quartzose strata of the same Lower Silurian series. So little indeed have some of these overlying beds the aspect of the old gneiss, that Prof. Harkness declares that they often reminded him rather of altered flags of Carboniferous age in Ireland. When, however, these same and other overlying beds are followed further eastwards, in their slight inclination, to the environs of Tongue, they here and there assume more gneissic characters than the strata which clearly lie beneath them,—a phenomenon which will be presently spoken of, when it will be shown that in the eastern region such strata are more altered and are infinitely more affected by the intrusion of large and extensive masses of igneous rock than in the north-western country.

Igneous Rocks of Sutherland.—The oldest igneous rock of Sutherland is the bright-red granite which, penetrating the fundamental gneiss in both large and small masses, seems in some places to be almost a constituent of those ancient rocks which compose the oldest or "Laurentian System."

Resting upon all this Laurentian or fundamental gneiss, the base of the Cambrian rocks of Canisp is characterized by the large-crystalled porphyry, first observed by Mr. Peach as clasping round the lower part of that mountain. This peculiar porphyry not having been detected in any overlying Lower Silurian rock, we may consider it for the present to be characteristic of the Cambrian age in the North-western Highlands.

No igneous rock has yet been observed to be associated with the lower quartz-rock of Assynt; but in the limestones which succeed a band of trap or syenitic greenstone has been noted at Inch-na-dampff, which dips with and conforms to the strata; and although there is no doubt of the intrusive character of this rock (seeing that here and there it greatly modifies the character of the limestone), still it in no wise interferes with the regular general succession of the strata.

Next, an igneous rock of felspathic character, with some varieties, which, though termed porphyries, are rather syenites (rarely true porphyries), breaks through the upper quartz-rocks far above the limestone of Assynt. In the tract to the east of Assynt which is traversed by the road to Oykel Bridge, they spread out into large

masses, as laid down in the accompanying map of Sutherland*, whilst some of them extend into Ross-shire. Again, Prof. Ramsay found such felspathic rocks in a similar position northwards near the head of Loch Coul.

However devious their outlines, and however much they are occasionally developed, these intrusive felstones never break up the order of succession, even where they are interwoven with the metamorphic Lower Silurian strata. Thus, if the observer, instead of selecting such transverse sections as those on which I have naturally insisted, as being the most free from such eruptive agency, chooses to pass over any of these igneous hilly masses in proceeding from west to east, he will still find the strata on both their flanks dipping to the east,—that is, to the S. or N. of east, according to the sinuosities and projections of the more ancient rocks upon which these Lower Silurian deposits were originally accumulated.

In short, the granitic felstones and syenites so largely developed in the eastern parts of Assynt, and which rarely if ever occur between the limestones and the upper quartz, but chiefly either in the latter or in the younger or overlying flagstones, no more hinder the observer from developing a clear and conformable order of superposition, than the true porphyries and other intrusive rocks have prevented the Geological Surveyors from working out the regular order of the associated Lower Silurian types of Wales†.

A most instructive lesson, in regard to the operation and effect of the intrusion of the red felstones, is to be seen at the Whiten Head, or maritime eastern headland of the noble bay of Loch Eriboll.

There, the quartz-rock series of the loch appears with its usual white aspect, when blanched by atmospheric action,—the cliffs with numerous caverns facing the bay being composed of that rock, without any associated limestone, which, as before said, thins out in its course from S.S.W. to N.N.E. On rounding the headland in a boat (a very calm day favoured us‡), the grandest scene, both for the painter and the geologist, was exposed to our sight. Numerous jagged rocks of quartz stand out—some pertaining to the mainland, others forming detached stacks in the sea,—one of which has a height of about 150 feet. Threading through these pinnacles and proceeding to the east, we found the whole of these white quartzose strata dipping eastwards or to the E.S.E., and then overlain by a great mass of dark chloritic and micaceous schist, which is penetrated in devious directions by eruptive bosses and veins of a light-red igneous rock, composed chiefly of felspar with some light-coloured quartz, certain veins of which cut across the strata, whilst others run parallel to them.

Although this eruptive rock has doubtless passed up through the stratified quartz-rock (one of the detached stacks exposing, indeed,

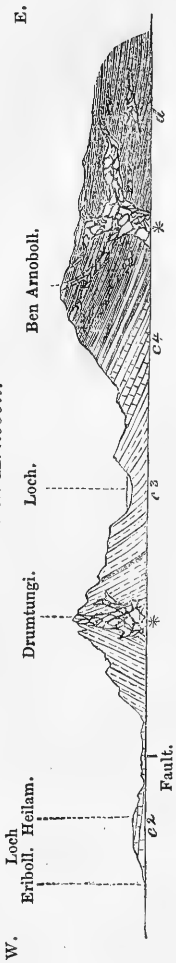
* This map was exhibited at the Meeting of the Society. The chief features are given in the reduced sketch-map, Pl. XII. in Vol. xv., published in No. 62.

† See the sheets of the Geological Survey Map of North Wales, and the illustrative sections.

‡ I passed under these cliffs in a boat with Prof. Sedgwick in 1827; but the sea was then too high to allow of our examining the rocks.

a shaft of felspar-rock covered by white and yellowish-white quartz), the red rock is a hundredfold more developed in the overlying dark-grey and greenish schists of the mainland (the "gneiss" of all previous geological maps). In fact, the schist is so permeated by the red intrusive matter, that it is mostly altered into a hard hornblendic flagstone; and yet the easterly dip is persistent. It is thus specially to be noticed that even this striking intrusion has not destroyed the order of succession; for even here, and particularly in the little bay called Geo-na-vore, the quartz-rock, dipping away at angles of about 45° to the east, having been denuded, is seen to be overlain conformably by the dark-grey and green chloritic and talcose schist, with its intercalated courses and veins of red and pink felspar-rock.

Fig. 10.—*Diagram-section showing the general Succession of Strata from Loch Eriboll eastward across Ben Arnoboll.*



c^2. Lower Limestone.
c^3. Upper Quartz-rock.
c^4. Upper Limestone.
d. Micaceous and gneissose rock.
* Igneous rocks. That of Drumtungi throws off the quartz-rocks; that of Ben Arnoboll does not affect the easterly dip of the strata.

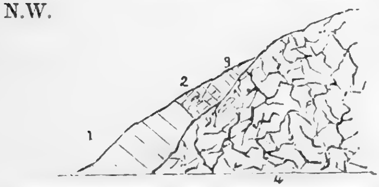
Similar proofs of the intrusion of these red igneous rocks are visible at several places between the Whiten Head on the N.N.E. and at Ben Arnoboll on the S.S.W., from which hill, to the ridge above Eriboll House, the felspathic matter thins away into the partial and evanescent layer of 3 feet above alluded to, and which alone is detectable at rare intervals in a consecutive parallel series, thousands of feet thick. In the hill of Drumtungi* (fig. 10), indeed, to the east of Heilam, the igneous rock is seen to intrude among the lower quartz-rock, the strata of which are placed in highly inclined positions; but on the east side of that hill, and immediately above a little loch, the limestone and quartz-rock, both dipping to the east, are conformably surmounted by regularly stratified masses of grey and dark-coloured talcose schists, in which the red felspathic rocks are nearly as much distributed as at the Whiten Head. This occurs in Ben Arnoboll; and on the southern side of that hill, when

* There is doubtless a powerful fault between the little limestone promontory of Heilam and the quartz-rock of Drumtungi Hill. But such dislocations are quite irrespective of the general succession.

viewed from Glach-adherie, or the Valley of Storms, all these masses can be clearly observed dipping together to the east. The general accuracy, therefore, of the section of Mr. Cunningham seems to me to be confirmed by an appeal to Ben Arnoboll, if the hill which lies to the east of Drumtungi be that to which that author referred.

Here we see the quartz-rock and limestone conformably superposed by what few geologists would call gneiss, but which would by most be named chloritic, talcose, and micaceous schists; these strata, whatever be their mineral character, are riddled by the intrusive rock, and in parts much altered and hardened, without producing any discordance between them and the subjacent quartz-rock and limestone. The manner in which the strata are affected at different parts of this Hill of Arnoboll is thus represented by Prof. Harkness. In the one case the quartz-rock and limestone are seen dipping conformably to the east against a large mass of eruptive felstone (fig. 11). In the other (fig. 12), the upper portion (the

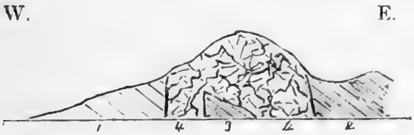
Fig. 11.—*Section of the Quartz-rocks and Felstone at Arnoboll.*



1. Upper Quartz-rock.
2. Upper Limestone.
3. Uppermost Quartz-rock.
4. Felstone (granitic).

quartz-rock) is seen to be followed on the east by altered schists or gneiss, both in the body of the intrusive rock* and at its eastern

Fig. 12.—*Section at Arnoboll.*



1. Upper Quartz-rock, dipping 40° E.
2. Gneissic strata, dipping 40° E.
3. Mass of gneiss enclosed in the granitic felstone.
4. Felstone (granitic).

flank: all the strata, however, whether broken or metamorphosed, are seen to dip conformably to the east.

Now, whether the generalized section, fig. 10, which I drew, or the details given by an independent observer, Prof. Harkness, taken from other parts where the eruptive rock is most expanded, be referred to, it is obvious that in neither is the easterly ascending succession interfered with.

These cases are the most remarkable examples known to me, and prove that, whether the intrusive rock shows itself in the lower quartz-rock, the intervening limestone, the upper quartz-rock, or the overlying schists or so-called "gneiss" (and in the Eriboll

* Prof. Nicol was indeed quite right in calling attention to the great mass of associated igneous rock, which Cunningham and myself had perhaps treated too lightly. But the very fact of its existence without producing any break in the general succession of the strata is, I think, a striking corroboration of our views.

district it is chiefly in the latter), it never breaks up the general succession, which, on the contrary, is still more clearly established by its persistence in spite of all such local intrusions.

If the quartz-rocks and limestones with Lower Silurian fossils had really been flanked on the east by a gneiss as ancient as that of the west coast, as represented in all previous maps, they must have been thrown into troughs. But nowhere, from the upper end of Loch Broom in Ross-shire to the eastern shore of Loch Eriboll and the northern sea-cliffs in Sutherland, is there any example that these flaglike strata, whether micaceous, quartzose, or gneissose, have such a reversed dip as would carry them under the Silurian quartz-rocks. On the contrary, the latter are everywhere overlain by the said flag-like, gneissose, or micaceous schists along a distance of seventy miles. Such overlying rocks, be they ever so metamorphosed or broken in upon by eruptive rock, can therefore no longer be represented on a map by the same colour and with the same letter as the fundamental gneiss. In fact, the term "gneiss," however good in lithological parlance, must be discarded by geologists, except in a mineralogical sense, just as "grauwacke" was eliminated from our nomenclature when that term was found to have been indiscriminately applied to rocks of various ages, from the Cambrian, through the Silurian and Devonian, to the Carboniferous inclusive. In other words, the day has now come, or is fast coming, when the various families of the Scottish gneiss, so minutely elaborated by Macculloch, will have their true ages assigned to them.

And now a few words on strata many of them higher in the series of the Northern Highlands than those already treated of. In the environs of Tongue, masses of igneous rock rise out which are vastly larger and loftier than any associated with the inferior portion of the metamorphosed Lower Silurian rocks. Thus, it was not merely in the mountains of Ben Lloghal*, to the south of Tongue, that Prof. Ramsay and myself found the syenitic and granitic rocks piercing through all the overlying strata having gneissose characters; but in our rapid survey we detected that the imposing mass of Ben Stomino, further to the east, and which has been represented in all geological maps as composed of Old Red Sandstone, was essentially granitic! On the flanks therefore of such grand eruptive masses—and they may extend over many moors and morasses where we did not follow them—it was quite to be expected that the contiguous strata should (as we found them) be much hardened and altered, and also often twisted into devious forms, much more resembling the older gneiss than any of the lower flaglike masses around Ben Hope. Yet, however metamorphosed, still the order of superposition continues,—the usual and prevalent dip being steadily to the E.S.E. or S.E. Even in these tracts, however, the gneissose character is not persistent; for, on moving eastwards from the environs of Tongue to the valley of Borgie Water, we again meet with interpolated micaceous flagstones, in which undulations and ripple-marks are obser-

* pronounced *Loyal*.

vable. Then in proceeding further east, the gneissose character, with many granitic intrusions, again prevails, fine laminæ of felspar alternating with quartz of white, grey, and pink colours.

On the west side of the Naver Ferry, granite here and there peeps out in small knolls through the strata, which dip gently to the E.S.E.; whilst at Betty Hill, on the right bank of the stream, the gneissose flags are raised to verticality and pierced by granite. In short, all the stratified rocks of the region extending from the Naver to Melvich, and thence ranging along the western borders of Caithness, must be classed with the newer gneissose flagstones, though they are penetrated at such numerous intervals by bosses of granite that it would require much time and good detailed maps to ensure their correct delineation. These rocks stretch out to Strathie Point, whilst to the north of Strathie Water the true Old Red Sandstone often rests at once on granite. (See Map, pl. 12, Vol. xv.)

Again, between Melvich and the Inn of Achintoul, and thence to the Ord of Caithness, Prof. Ramsay and myself found these granitic outbursts to be so numerous, that we had no difficulty in comprehending why the overlying masses (in which there were numerous undulations and breaks) should be much more metamorphosed than in the western portion of the same series of strata where the igneous rocks are much less rife.

The Eastern Gneissose Rocks of Sutherland and Ross.—The metamorphic condition of the old stratified rocks which extend eastward from Sutherland into the edges of Caithness is well seen at and around the Scarabin Hills, and has been before adverted to*. On the south-eastern flank of the Scarabins, various stages in the degrees of change may be traced, from slightly altered grey-coloured micaceous quartzites up to the highly crystalline quartz-rock, which is void of mica and is penetrated by much granite,—the prevalent dip being to the S.E. and S.S.E.

Again, in tracts further to the south along their eastern frontier, these stratified crystalline rocks are well seen to the west of Golspie and Loch Brora. There, at the head of Dunrobin Glen, the finely grained, thin-bedded, quartzose rocks, which are laid down as gneiss in geological maps, consist of rugged bosses with many joints, and so abundantly penetrated by granite that it is difficult to trace the true bedding.

In the upper part of Strath Brora, however, the strike of these gneisso-micaceous rocks is manifestly from W.S.W. to E.N.E.† In crossing the River Brora above the house of Kil-callum-kil, this gneiss is admirably exposed in a gorge watered by a torrent which flows down from the flank of Ben Smeorale into the Loch of Brora. The strata are then thrown off to S. and N. of E., at various high angles from 50° to 70°,—numerous huge masses of granite being seen to intrude upon the beds. In tracing the stratified crystalline rocks from W. to E., or from N.W. to S.E., it may therefore be truly said

* See Quart. Journ. Geol. Soc. vol. xv. p. 384.

† If subsequent researches should prove that some of this eastern gneiss pertains to the old or fundamental rock, the fact would in no wise invalidate the truthfulness of the described succession in the north-western parts of Sutherland and Ross.

that their degree of metamorphism bears in several tracts a close relation to the amount of granite which has been intruded among them, and that thus the eastern rocks which overlie the western deposits have been rendered more crystalline than those of older date. At the same time there are wide tracts of country where the upper or flaggy gneiss is in a highly crystalline state, and yet where the observer is unable to detect any granite, porphyry, or other purely igneous product in the proximity. For, after all, such eruptive rocks are merely to be viewed as the occasional signs of the effusion of that great internal heat, which may have accompanied the metamorphosis of a whole region of stratified rock without being the sole, or even the main cause of the great change, which probably resulted from a combination of electrical and other forces.

Hypothetical view respecting the gneissose rocks of the Southern Highlands.—Having come to the above conclusions respecting the age of the eastern gneiss of Sutherland and Ross, I venture to suggest that nearly all the eastern gneiss of the counties of Inverness, Nairn, Moray, Banff, and Aberdeen, as well as many stratified rocks of the Southern Highlands, may prove to be younger than the fossiliferous quartz-rocks and limestones of the North-west.

Not having carefully examined the chain of the Grampians, I cannot pretend to say that some of the fundamental gneiss and older granite may not be there partially exhibited. But I hold it to be highly probable that the so-called gneiss which ranges along the edges of the Old Red Sandstone of Moray and Banff, and is seen on the banks of the Spey where crossed by the railroad, and thence extends to the east coast, belongs to the younger gneiss, and that the micaceous flags (not slates) east of Fochabers, and the clay-slates extending from Foundeland to the tracts south of Huntley, are simply different members of the same Lower Silurian strata. The clay-slates are, indeed, so little metamorphosed, that I cannot but believe that Graptolites or other fossils will some day be found in them. Again, on the eastern flanks of the Grampians, wherever I examined these clay-slates, I found them to be simply thin argillaceous flags, void of cleavage, with intercalated courses of limestone; nor could I comprehend how, by the smaller or larger quantity of mica, great lithological distinctions could be maintained along definite zones,—so much does one of these classes of rock graduate into the other. Furthermore, I observed in the glens which enter into the south-eastern flank of the Grampians, various bosses and bands of eruptive porphyry which are marked on no map, but which have doubtless served so to modify the strata, that the transition from one lithological character to another, as from clay-slate to mica-schist, and from the latter into the so-called gneiss, becomes so devious and irregular, that it is almost impossible to lay them down in separate zones on any map now extant.

And here I must take the opportunity of again expressing an opinion which I put forth at the Glasgow Meeting of the British Association in 1854, and which has been reiterated in the last edition of 'Siluria,' and also in my last communication to this Society. It is,

that, with the exception of rare and insulated cases, as in the slate-quarries of Easdale, Ballyhulish, &c., on the west coast, there is scarcely a trace of true slaty cleavage throughout the vast masses of the crystalline stratified rocks of the Highlands. Deeply lamenting that my able and zealous friend the late Mr. D. Sharpe should, after a hasty survey, have been led to express the broad views on cleavage which are printed in the 'Philosophical Transactions*,' I was for some time unwilling to advert to a subject on which I held opinions so very much opposed to his own; but now that I find Prof. Ramsay, who is so well acquainted with the slaty rocks of North Wales, completely agreeing with the views which Prof. Sedgwick and myself long ago expressed, I can no longer forbear from pointing out what I am compelled to consider an error. In fact, there can be no sort of doubt that the different stratified masses of the Highlands have resulted from successive depositions of mineral matter, which, though subsequently much metamorphosed and also traversed by numerous joints, have in the rarest cases only assumed a true slaty cleavage.

Conclusion.—I may now revert to the main object of this memoir, the establishment of a clear order of succession among the oldest rocks of the North-western Highlands. And here I have the satisfaction to reiterate that not only Prof. Ramsay, who accompanied me, but also Prof. Harkness, who has since visited the north-western region to satisfy doubts in his own mind, have both come to the conclusion that my general views (as laid down in the map, Pl. XII. vol. xv.) are correct.

On a point of such great stratigraphical importance, I cannot avoid quoting the very words of Prof. Harkness, who, after visiting the west of Sutherland, wrote to me thus:—"The gneiss which occupies the western portion of Sutherland is of a character so unlike that which forms the more eastern mountains of this country, that lithological characters alone would almost justify the conclusion that it appertains to a different geological epoch. Its strike is, as you have shown, at variance with that of the newer gneiss where this latter is in contact with the quartz-rocks and limestones forming the Lower Silurians.

"At many localities where the surface allows of the relation of the upper gneiss and its immediately underlying deposits to be seen, there is undoubted evidence of a perfect sequence and conformity of the strata which appertain to the upper quartz-rock and limestone and the overlying flaggy gneiss; and this latter, in some districts remote from the quartzites and limestones, presents the same uniform dip with the rocks on which it reposes, as seen in Ben Hope and the extensive country to the S.E.

"All the circumstances in connexion with this flaglike gneiss prove it to be a member, superior in position, but intimately allied, of the Lower Silurians of the N.W. of Scotland. The mode in which the felspar-rock is found in relation to this gneiss at Eriboll indicates that no great line of dislocation separates the upper quartzites and

* Vol. cxlii. p. 445.

limestones from the so-called gneiss, since it is *through this latter* that the felstone penetrates, and not through a line separating this from the quartzy or calcareous deposits."

The changes which are involved in the adoption of my views of the order of succession are, it will be admitted, considerable. In the first place, by showing that mountain-masses of sandstone and conglomerate lie unconformably beneath quartzose and calcareous rocks with true Lower Silurian fossils, we know that the former must be of Cambrian age. We further learn that the old or fundamental gneiss, which lies beneath such Cambrian sandstone, and is entirely unconformable to, and independent of it, is a lower stratified rock than any hitherto recognized in the British Isles. The beginning of the geological alphabet, as applied in the Maps of the Geological Survey to the Cambrian rocks of England, Wales, and Ireland, must therefore be preceded in Scotland by the first letter of some alphabet earlier than the Roman, showing a still lower deep in the north-west of Scotland (as in North America) than exists in England, Wales, or Ireland.

If this most ancient gneiss required a British name, it might indeed with propriety be termed the "Lewisian System," seeing that the large island of the Lewis is essentially composed of it, capped here and there by derivative masses of Cambrian conglomerate; but the term "Laurentian" having been already applied to rocks of this age in North America by our distinguished associate Sir W. Logan, I adhere to that name, the more so as it is derived from a very extensive region of a great British colony.

Having proved that the fossiliferous Lower Silurian zone is conformably surmounted by various crystalline flaglike strata, it follows that the latter, though formerly looked upon as among the most ancient rocks, must be simply viewed as other and younger masses of the same natural Silurian group, but which have undergone such an amount of metamorphism as to have obliterated the traces of any animals which once inhabited the seas in which the strata were accumulated. A glance at the little map* and table of colours, Pl. XII. vol. xv., and a comparison of them with all preceding maps and publications, will at once explain the changes which I have endeavoured to effect. The leading features of these changes I first sketched out in the year 1854 at the Glasgow Meeting of the British Association, and afterwards dwelt upon them at the meeting of that body at Aberdeen in the autumn of 1859.

Lastly, I would repeat the suggestion which I have before thrown out†, that the stratified rocks of the north of Scotland are for the most part equivalents in age of the Lower Silurian rocks of the southernmost Scottish counties, the strata of which, having been only partially altered, and having been left in the mineral condition of "grauwacke," naturally exhibit much more frequently the evidences of fossil organic remains than their highly crystalline and metamorphosed representatives in the northern Highlands.

* Published in No. 62 of the Quart. Journ. Geol. Soc.

† Quart. Journ. Geol. Soc. vol. vii. p. 169 (1851).

NOVEMBER 30, 1859.

Sir Walter James, Betshanger Park, Kent; George Dawes, Esq., Milton Iron-works, near Barnsley, Yorkshire; The Rev. Julian Edmund Woods, Penola, South Australia; Bassett Smith, Esq., 1 Elm Court, Temple; Captain W. Hichens, Bengal Engineers; Lionel Brough, Esq., one of H.M. Inspectors of Coal-mines, Clifton; John Studdy Leigh, Esq., St. Stephen's Terrace, Bayswater; and John Pope Hennessy, Esq., M.P., were elected Fellows.

The following communications were read:—

1. *On some* BRONZE RELICS *found in an* AURIFEROUS SAND *in* SIBERIA. By T. W. ATKINSON, Esq., F.G.S., F.R.G.S.

THE accompanying fragments of worked metal* were discovered in Siberia, at a gold-mine on the River Shargan†, in about lat. 59° 30′ N. and long. 96° 10′ E. They were found at a depth of 14 feet 8 inches beneath the surface, near the middle of a bed of gold-bearing sand‡, which was 20 inches thick, and composed of yellow sand, pebbles, small fragments of quartz, with other pulverized or decomposed rocks. Imbedded in it were pieces of gold, varying in size from small grains to nuggets of one to four pounds in weight. This deposit rested on a bed of rock.

Immediately above the sand there was a stratum, 5 feet in thickness, consisting of coarse gravel, dark-coloured sand, and some earthy matter, containing pieces (but not of large size) of quartz, granite, and porphyritic rocks. Overlying this, there was another stratum, 6 feet in thickness, composed of yellow sand and rough pebbles, in which were imbedded blocks of granite, porphyry, and jasper. Some of these were large, and their angles were worn away by attrition. Over this was a bed of dark-coloured sand, about 10 inches thick; and above that, 2 feet of good vegetable mould, formed by the decayed trunks of trees and herbage.

There were no fissures in the strata through which these bronze relics could have fallen, nor did they appear to have ever been disturbed by man since the gold was deposited.

The relics were found in the presence of one of the officers of the mine, and secured by him, or they would probably have been taken to the gold-washing machines and lost. I saw them within half an hour of their discovery, and with some of the matrix (sand and gravel) still adhering to them. The Director and the miners, as also myself, were fully convinced that these pieces of metal had been carried to their resting-place by the stream which had washed down the gold.

* Exhibited at the Meeting.

† The Shargan, which has often shifted its course, runs into the Toungous at about 40 miles below the spot here referred to as the place of the gold-diggings; the latter river ultimately joins the Yenissey. This gold-mine is about 150 miles from the town of Yenissey.

‡ Remains of Mammoths are said to occur in this sand, about half a mile off.

The country was covered with a dense forest of cedars, pines, poplars, and birches, extending for several hundred miles, but few parts of which have yet been penetrated. Near the edge of the excavations, cedars 4 feet in diameter were growing; and vast numbers, of still larger dimensions, had been cut down on the site. I have seen cedars in these forests 7 feet in diameter at 4 feet above the ground.

The above are extracts from my journal,—mere facts. As I have no theory to establish, I give them without any speculations as to the period when these relics were deposited in the sandy gold-bearing bed. I may, however, add, that the Director of the mines supposed these pieces had formed a part of some horse-trappings; but my own impression is that they had belonged to a bracelet. By examining the larger fragment, it will be seen that it is decorated with foliage. The metal is bronze*.

I possessed several other pieces, one of which was a wedge-like part which fitted into the unbroken ring. But unfortunately all were lost on my journey, excepting those which I have enclosed for inspection. Some other parts were shattered by the pick-axe, taken to the gold-washing machine, and lost.

These fragments were found on the 26th of August, 1851, during my stay at the gold-mine. I saw the place whence they were taken, and the Director most kindly presented them to me.

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2. *On the* Volcanic Country *of* Auckland, New Zealand. By Charles Heaphy, Esq., Provincial Surveyor, &c.

(Communicated by the President.)

[Plates XII., XIII.]

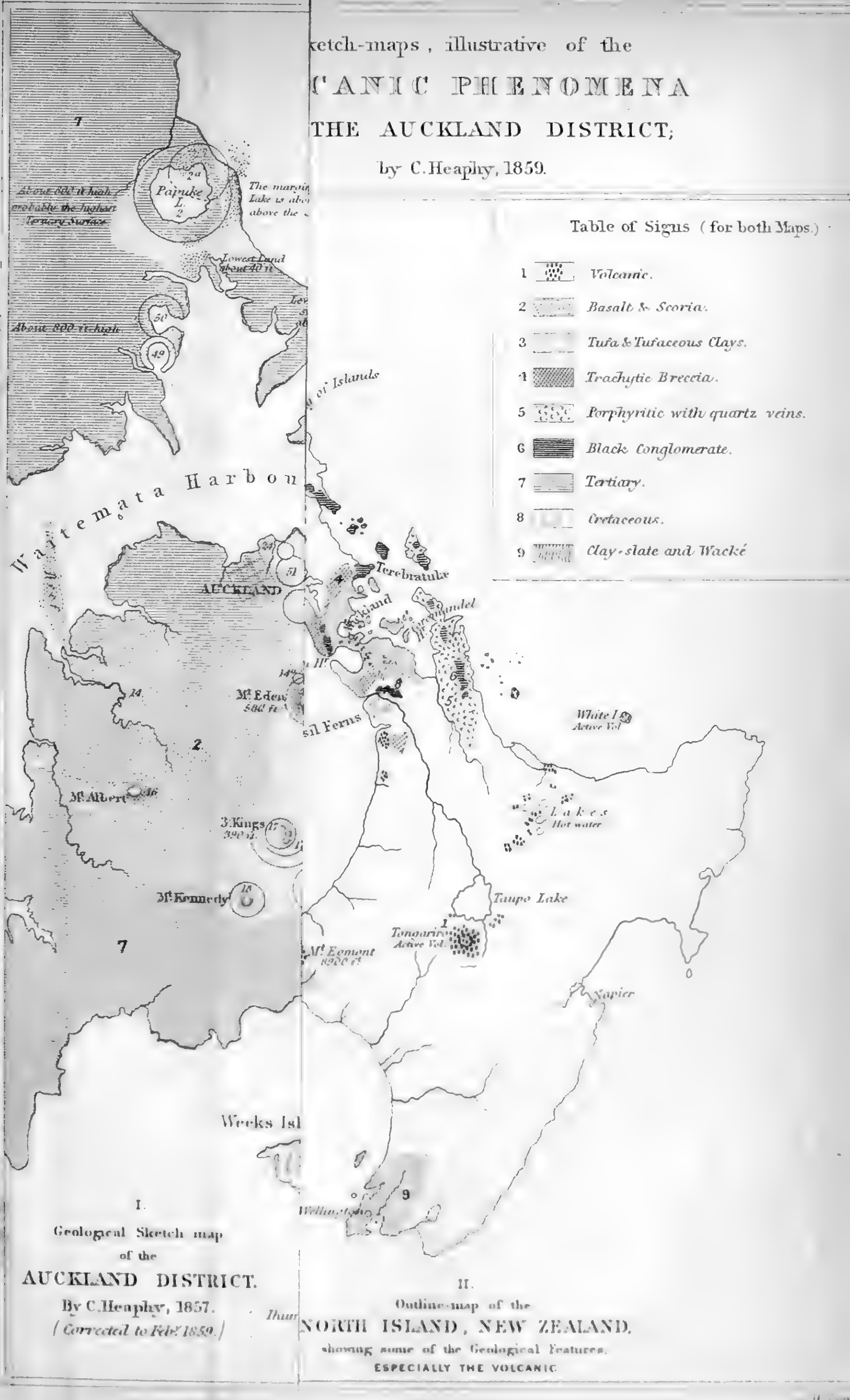
By the map of New Zealand it will be seen that in the 36th degree of south latitude the Northern Island of New Zealand is so much narrowed as to form an isthmus of about six miles in width from east to west, connecting the broader and higher land on either side.

This isthmus, like the land immediately to the north and south of it, has an undulating surface, rising in some places to hills of about 600 or 700 feet above the sea. The cliffs which bound its eastern side show beds of soft sandstone, indurated clay, and mud-rock, with layers of volcanic ashes, and, occasionally, seams of lignite and coal. The whole seems to belong to the Tertiary formation, and probably to the Eocene period. Organic remains are rarely met with. But at one locality, between Kohuroa and Omaha, *Terebratulæ* (of which specimens are forwarded to the Society) occur at the junction of the volcanic ashes and clay-beds above-mentioned.

The higher land to the south of the isthmus—beginning on the eastern coast—consists of, first, clay-slate, then rocks of the Creta-

* As determined by Dr. Percy, F.G.S., Nov. 30, 1859.

ketch-maps, illustrative of the
CANIC PHENOMENA
THE AUCKLAND DISTRICT;
by C. Heaphy, 1859.



I.
Geological Sketch map
of the
AUCKLAND DISTRICT.
By C. Heaphy, 1857.
(Corrected to Feb.y 1859.)

II.
Outline-map of the
NORTH ISLAND, NEW ZEALAND,
showing some of the Geological Features,
ESPECIALLY THE VOLCANIC

Sketch-maps, illustrative of the

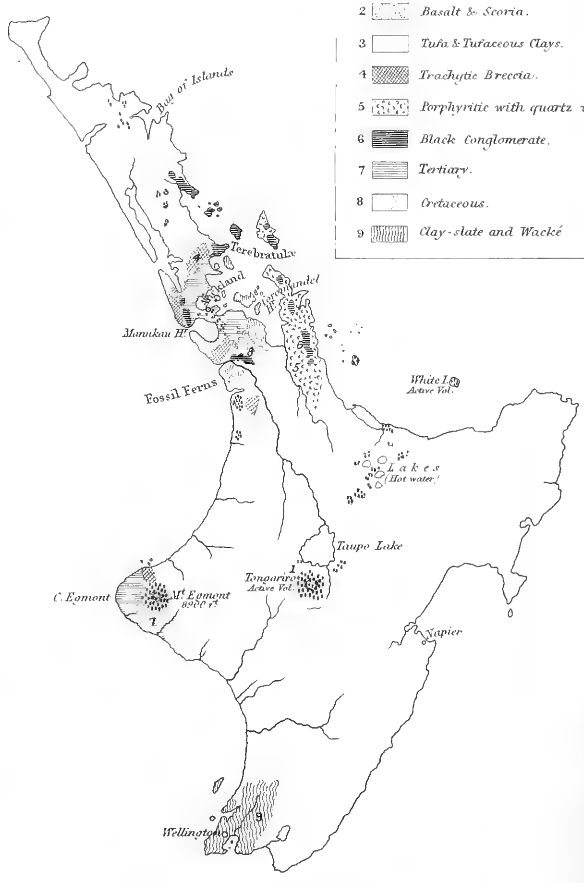
VOLCANIC PHENOMENA OF THE AUCKLAND DISTRICT;

by C. Heaphy, 1859.

I. Geological Sketch-map of the AUCKLAND DISTRICT. By C. Heaphy, 1857. (Corrected to Feb. 1859.)

Table of Signs (for both Maps.)

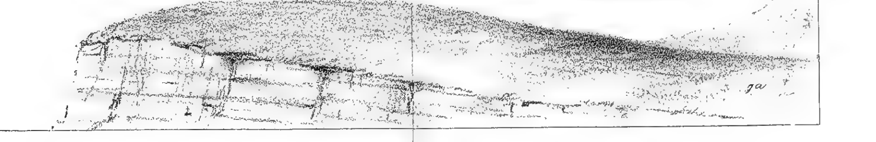
1	Volcanic.
2	Basalt & Scoria.
3	Tufa & Tufaceous Clays.
4	Trachytic Breccia.
5	Porphyritic with quartz veins.
6	Black Conglomerate.
7	Tertiary.
8	Cretaceous.
9	Clay-slate and Wacké.



II. Outline-map of the NORTH ISLAND, NEW ZEALAND; showing some of the Geological Features, ESPECIALLY THE VOLCANIC.

J. W. Lowry, sc.

THE NORTHERN SHORE OF AUCKLAND, NEW ZEALAND.



1. Rangitoto Island. Scoriæ & Basaltic lava.
2. North Head. An old scoriaceous water-worn crater; with volcanic bombs scattered over the side.
3, 4, & 4a Mount Victoria
4b Basaltic lava
5 Pupuka Lake (Freshwater). A scoriaceous, basaltic & tufaceous crater.
6. Island of Kawau
6a Tertiary Cliffs. 6a & 6b Clay-slate. A Copper-mine at 6c
7 Tertiary Cliffs of Auckland Harbour
7a Tertiary. 7b Recent sandy beach
8 Little Barrier or Mount Many-peaks. Basaltic.
9. Motutapu Island, Tertiary, with trap-dykes.
10 & 11 Waiheke & Urakino Islands. Clay-slate & wacké.
12. Great Barrier Island. Basaltic.
13 Mahurangi Range; and
14. Mount Hamilton. Basaltic and Trachyte.

I. II. III. IV. Volcanic rocks and craters of the First, Second, Third, and Fourth periods of eruption.

Lithographed at the "GEOLOGIST" Office, 156, Strand

ceous formation, and lastly, a magnetic sandstone-rock, mixed with a black conglomerate. This series rises into hills of 800 or 1000 feet above the sea.

To the northward of the isthmus the Tertiary is bounded on the eastern slope by a black trap-rock of a very close texture, next by a black boulder-rock, and finally, on the west coast, by a trachytic breccia, rising into peaks and ridges of from 700 to 1500 feet high.

To the eastward of the isthmus are several islands, in the Gulf of the Thames, composed of clay-slate, of basaltic lava, and of the black boulder-rock. The latter rises into peculiar sharp crags, at a height of 1000 feet or thereabouts.

The isthmus may be considered as a basin of Tertiary rock. Through it have burst up, dotting its surface, as many as sixty-two separate volcanos; showing in nearly every instance a well-defined point of eruption—generally a cup-like crater, on a hill about 300 feet high above the plain.

In some instances there are as many as four points of eruption in the compass of a square mile,—the streams of lava commingling or overlapping; and the former crater in some cases filled up by the ashes from the more recent one.

On an examination of these volcanos, differences of age become at once apparent; and the relative position of their respective beds of ashes in the surrounding rocks facilitates the inquiry as to their priority of eruption. They may be classed as follows:—

1st. The eruptions, on a stupendous scale, of the mountain-masses with boulder-rock, rising to a height of 1000 or 1500 feet above the Tertiary basin; and perhaps coeval with this was the rising of the trachytic breccia. The relative ages of the black boulder-rock and the trachyte, in respect to the Tertiary beds, must remain for a time doubtful. At present there is no appearance of the trachyte having been more recent than the Tertiary, save that it is in one place superimposed; and this, perhaps, is only its debris, consolidated. The trachyte shows no difference of texture below or above. There are abundance of dykes in it, but no craters; and while it has risen to a height of 1400 feet in peaks, there is no high mountain on any side to wall-in the igneous mass. The peaks have not in any way the appearance of the broken parts of the brim of a crater; they rather look like the hardest parts of dykes,—the softer contiguous rock having disappeared.

2nd. Subaqueous eruptions through the Tertiary beds at the time when they were yet submerged. The ashes of these eruptions form horizontal and extended beds below some of the Tertiary clays, and are conspicuous for miles along the cliffs on the east of the basin.

3rd. Eruptions that have occurred at the upheaval of the Tertiary beds. These are generally situated on the line of the cliffs, or over faults in the Tertiary strata; and,

4th. Eruptions through the Tertiary strata.

I. Of the first class (the black boulders and trachytes) no points of eruption or craters can be traced, or anything approaching the cra-

teriform shape. The trachyte-rocks stand in a huge mass on the flank of the Tertiary formation, rising high above them with fantastic, in some cases overhanging peaks.

The surfaces of the boulder-rock and the trachyte are of very compact texture, seeming to indicate the existence, as the mass cooled, of immense pressure as well on the sides as on the summit, occasioned by matter perhaps of a more destructible nature which has since been removed, probably by denudation.

II. Respecting the second class of eruptions, the lavas of which constitute part of the Tertiary series, the general characteristics are, first, a great smoothness or worn-down appearance of the cones and craters; the cup having been filled up, and the brim having been broken away. The points of eruption are indicated usually by some slight hollow, but chiefly by the streams of basalt and scoriæ that centre there. The whole cone, consisting probably of loose cinders, has been washed away, and its remains are spread along for miles, in some cases, between the beds of clay; carrying with it fragments of Tertiary rock, unaltered, but rounded: beds of indurated mud are again superimposed on these. The volcanos Nos. 24 & 51 on the Geological Sketch-map (Pl. XII.) are instances of this.

Of these Tertiary volcanos some have, perhaps, been not altogether subaqueous, but have raised their cones above the water, as in the case of the North Head at Auckland Harbour (No. 5 on the map, Pl. XII. See also the drawing, Pl. XIII.).

In this case no clays are superimposed, but the surface over the lower beds of ashes is of that horizontal character which indicates the action of water as the ashes fell, or before they were consolidated. Around the sides of this crater, the tails of the volcanic bombs are more perfect (less injured by the fall) than could have been the case, I think, if they had descended into anything but water. The lavas of the submarine eruptions appear more compact than those of the recent volcanos. Nothing like cellular scoriæ has yet been found among the cinders of this class.

III. The third class of volcanos *here* may be considered to be those that came into eruption when the Tertiary was upraised. They lie on the edge of cliffs, or on the prolongation of the line of a cliff that has dipped into the sea, as in the sketch (fig. 1).

The lavas of these have an older and more decomposed appearance than those of the fourth class, and the craters have always broken out towards the lower or seaward side.

In one instance, where there is a remarkable fault in the Tertiary rock, eruptions and a crater have resulted, the deranged strata dipping *towards* the point of eruption (fig. 2).

The fourth class, or those eruptions that have come up through the already upheaved Tertiary rocks, show the greatest variety of form and conditions,—a result perhaps only attributable to their having been less affected by time and disturbances.

IV. The volcanos of the fourth class may again be systematized as follows:—

1. Tufa-craters, of but very slight elevation.

Fig. 1.—*Sketch showing the relation of the Craters and the Cliffs near Auckland.*

Fig. 2.—*Crater and Lava-stream in a Fissure of the Tertiary Strata.*

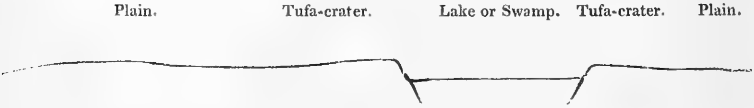
2. Basaltic and scoriaceous eruptions, of a sluggish nature (wellings-out), which have caused but little elevation, and no cone.

3. Cones with cups; of various compositions.

1st. Of the tufa-craters there is a greater variety in respect to size (diameter) than in any of the other classes. The Pupuke Lake (No. 2 on the map, Pl. XII.) is three-quarters of a mile in diameter between the walls of the crater, while the little Pond-crater, No. 7, is only 30 yards across.

These craters are generally either filled with water or with a swampy soil, and all show the characteristic section seen in fig. 3.

Fig. 3.—*Diagram of a Tufa-crater.*



In eight instances the broad tufa-crater contains within it a second point of eruption, constituting a cone, generally isolated, unless connected with the margin by the lava-stream which it has emitted. Mount Richmond, No. 25 on the map, is an illustration of this.

It is worthy of remark that in many cases the tufaceous craters seem, from their copious supply of water, to be fed by springs on which local rains seem to have but little immediate influence. In the case of the crater No. 25, the water is always running, and is of a pure quality.

The tufa-crater is often nearly filled up by the lava-stream from its central cone, or by the eruptions of some contiguous volcano.

2nd. The volcanos of this subordinate class are few, or, perhaps, their immediate points of eruption are but rarely apparent, from the circumstance of their being covered by the lava that has flowed out of them.

Apart from other volcanos, or high above the level of other lava-streams, are large ridges of basalt or scoriæ, bearing a surface-ripple, formed during the consolidation of the fused mass. By *ripple-mark* I here mean such concentric rings or ridges of surface as may be seen on slag that has cooled undisturbed after flowing from the furnace, as shown in fig. 4.

Fig. 4.—*Concentric Markings on the Surface of a cooled mass of Lava or other molten matter.*

In these cases the molten matter seems to have welled out slowly, without any projectile force or much vaporous explosion. No. 14,

and especially No. 42, on the map, Pl. XII., are instances of this. In the latter the eruption has taken place between two streams, and the lava has flowed to the confine of each, and there cooled.

In many cases the actual points of eruption must be hidden by the matter that has flowed out, while the contiguity of the edges of lava-streams flowing from other craters has destroyed the insularity of the emitted mass. The most interesting, however, of these phenomena are where, after a period of eruption, a partial collapse has taken place, and the crater (if it may be so called) has subsided within itself: I think the point No. 20 on Pl. XII. may be considered as of this kind.

The 3rd subclass of the fourth series is the elevated conical hill with its crater. I will describe three kinds, each of which may be considered as a type of several others that occur in the district.

a. Mount Albert (No. 16 on Pl. XII.) is a mound, about 350 feet above the sea, the base of the cone being about one-third of a mile in diameter. The crater is about 80 or 100 feet deep, and the lip on the S.W. side is broken away. A lava-stream has flowed out on this side, and continued its course along one of the natural valleys, over the Tertiary clays, to the sea at Auckland Harbour, a mile and a half to the N.W. The lava-stream has not expanded much laterally, perhaps on account of a stream and a swamp that touched its sides; but it has kept on its way, rolling, as it were, within partially cooled sides, until it reached the sea, where its course is for the present lost.

A question perhaps arises, as to whether this lava-stream flowed out of the crater through the present gap, which its weight caused to give way; or whether the cone resulted from an eruption of ashes subsequent to the welling-out of the lava-stream. In some instances (Mount Smart, No. 22 on the map, Pl. XII.) the lava-stream leaves the mountain at a point opposite to the crater-gap, as if the piling-up of the cone were subsequent to the basaltic eruption. There is but one section of a crater yet discovered (No. 45 on Pl. XII.) where the effect of the tide has broken away one side of the cone; and the section here has since been made more perfect by quarrying operations. See fig. 5.

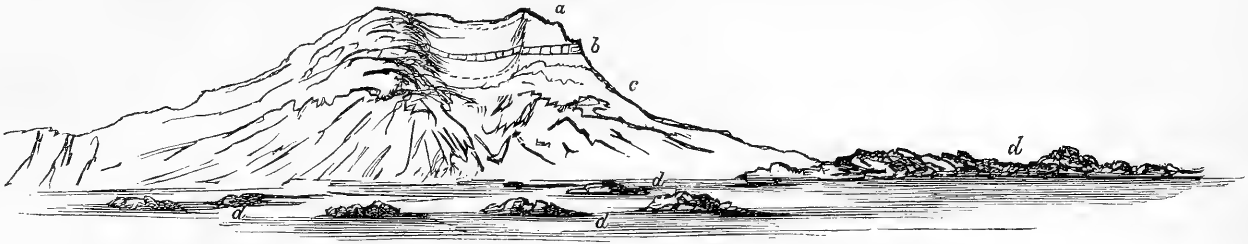
In this case, I think it is evident that the basaltic lava rose up to *b*, where it flowed over the sides; but those sides, especially at *c*, were so steep as to cause a severance of the stream, and the lava rolled down at once to *d*. It may be a question whether the bed *a* was subsequently added, or the basalt, *b*, found its way through, at intervals, without disturbing *a*. The great compactness of texture of the surface of *b* leads, perhaps, to a belief in the latter alternative.

b. There are near Auckland about four instances of cones with lateral craters.

The larger mound in fig. 6 shows a well-formed, but broken-down crater; a subordinate mound also shows a crater; a third shows no cup, but a lava-stream flows from the base of it; and a fourth and fifth show protuberances without apparent craters.

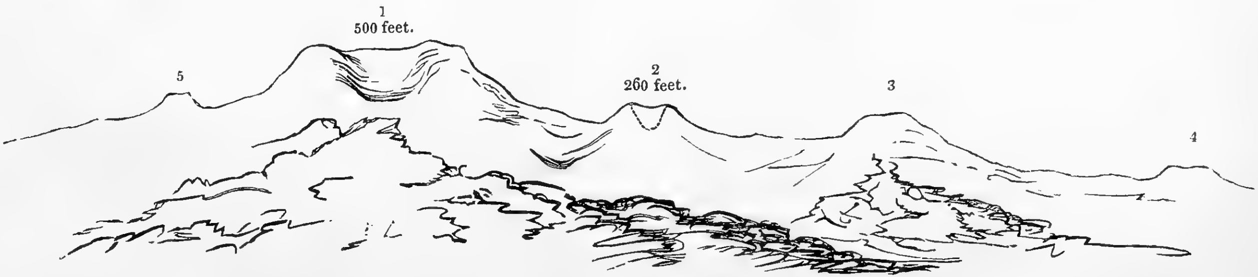
Are Nos. 3, 4, & 5 in this diagram (fig. 6) hills once containing craters that have been filled up by the subsequent raining-in of ashes

Fig. 5.—*Natural Section of a Crater on the North Shore of Auckland Harbour.* No. 45 on the Map.



a. Small cinders or puzzolana.
b. Bed of compact basalt, about 2 feet thick.
c. Dust, scoriæ, and masses of basalt, heaped promiscuously.
d. Scoriæ and basalt on the beach and in the sea.

Fig. 6.—*Volcanic Cone with lateral Craters, near Auckland.*



from Nos. 1 & 2? or are they dome-like risings, from the pressure of a dyke below? These subordinate craters do not range on the same line with each other and the large one.

c. No. 1 on the map, Pl. XII., or Rangitoto Island (see also Pl. XIII.), is a good type of another class, where successive eruptions, each feebler than the preceding, appear to have taken place from the same vent.

By the first eruption of this volcano the whole base of the island seems to have been constituted. The scoriaceous matter erupted appears to have heaped itself up until the last scoriæ flowed over a crater-lip about 600 feet above the sea. It was then entirely a scorial island (1 *b*, in Pl. XIII.), without any trace of tufa, or of small cinders, and the scoriæ sharp and clean, and almost vitrified on the surface. The second period of eruption heaped up a cone of ashes upon this (1 *a*, in Pl. XIII.).

This second eruption appears to have been but feeble, for the ashes from it are not diffused over the island. Indeed, in some parts of the island there is such an absence of small cinders that vegetation cannot exist, for want of a suitable substance in which to spread a root. A third eruption now took place; the sides of the cone were broken down by some sluggish lava-streams; and a new cone (1, in Pl. XII.) within the last became formed, its highest point being 920 feet above the sea.

The crater of the highest cone is about 200 yards in diameter, and about 100 yards deep. The scoriæ are very sharp, and also wholly undecomposed.

Another interesting example is met with in Mount Wellington, of which a sketch-plan is annexed (fig. 7). Here the tufa-crater, A, appears to be the oldest; it is nearly circular, with a swampy hollow (*a*), containing a central cone with a partly obliterated crater. The great crater, B, seems then to have come into action; and subsequently the subordinate crater, D, which has thrown out a stream of scoriæ, E, to the eastward. This has run into, and partly filled, the hollow, *a*, before it found an outlet to the northward.

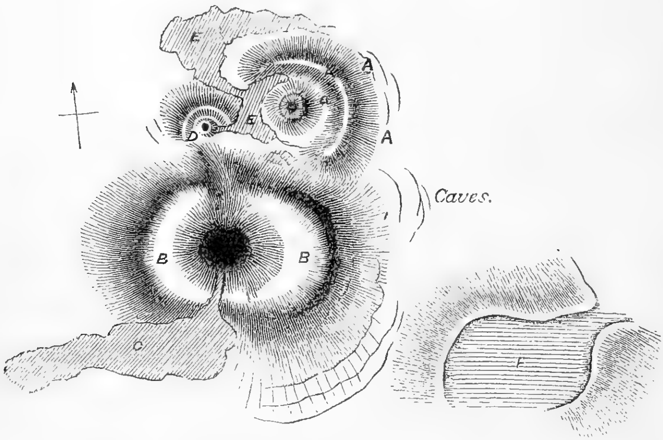
The question now remains,—how long a period has elapsed since the most recent of these volcanos has been in activity, and are they finally extinct, or merely quiescent? The relative ages of the different eruptions may be easily determined by careful observation; but the lapse of time since the last took place cannot now even be fairly guessed at.

It would, however, appear that the Island of Rangitoto was one of the latest in operation. And though the natives have no traditions of this mountain, or indeed of any about Auckland, having been in a state of activity, yet the name which it bears—and conspicuously in their old songs and traditional stories—is most significant. Rangitoto means, literally and simply, "Bloody Sky." Thus, *Rangi*, sky; *toto*, bloody—a term never used to indicate the red sky of evening or morning.

The traditions of the New Zealanders yield evidence that the

people have had a common origin with the Sandwich Islanders. The language has but a slight dialectal difference from the Hawaiian; so slight, indeed, that a separation of people for four or five centuries might be presumed to have caused a greater; and if it can be established that Rangitoto has been in eruption since the coming of the Maori, ethnologists may, perhaps, ere long assist in ascertaining their date. Leaving, however, this speculation, I may mention that fern-root (*Pteris esculenta*) has been found by well-diggers, uninjured, at a depth of 15 feet below a bed of scoriæ, near Mount Eden; and that charred bones, apparently human, were found on the edge of a lava-stream, and protruding from the mass, which had cooled about them.

Fig. 7.—*Sketch-plan of Mount Wellington and Waipuna Lake, eight miles east of Auckland.*



A. Tufa-crater. *a*. Swampy hollow. B. Tufa-crater, about 400 feet high. C. Lava-stream. D. Recent crater, about 200 feet high. E. Lava-stream. F. Lake Waipuna, an old Tufa-crater.

Earthquakes (common and occasionally violent in the neighbourhood of Wellington—a clay-slate and granitic country) are here unknown, or of doubtful remembrance. Are we to conclude that the numerous volcanic vents have given off all that was of an expansive or disturbing nature, and that they are really extinct? In the Bay of Plenty, at a distance of about 140 miles, is White Island, a volcano of considerable activity; and in a chain from that to the great inland volcano, "Tonge Riro," exist many geysers and solfataras, all active. Has the volcanic effort become transferred to these—and are they the safety-valves of the Auckland country? Observation may yet show whether these have come into activity since the cessation of eruption at Auckland. The buried plants and bones may unfold a page in their relative history.

Notes on the Fossils.

Among the specimens sent by Mr. Heaphy are some

Terebratulæ (of large size) in a calcareous rock, from the Wairou Valley.

Terebratulæ and *Bryozoa*, from Kohuroa, near Cape Rodney.

Belemnites (sulcated), *Bryozoa*, and a Fern (*Pecopteris*?), from seven miles south of Waikato Head.

Brown-coal from Slippery Creek (Farmer's Land), and from Wangaparou Promontory.

Lignite from a section at Orakei Creek, Auckland; where clay (with streaks of lignite), volcanic ash (15 ft.), sandstone, clay, and lignite succeed one another (from above downwards).

Also a fossiliferous, friable, argillo-calcareous grit, full of green grains (the casts of small organisms, especially of *Foraminifera*). It contains fragments of *Salicornaria*, and of spines of Echinoderms; also casts of *Tubulipora* and small Univalves; and the following *Foraminifera*:—

Nodosaria Raphanistrum, Linn. (Fragments.)
Vaginulina Legumen, Linn. (Common.)
Polymorphina lactea, W. & J.
Cristellaria rotulata, Lam. (Common.)
Amphistegina vulgaris, D'Orb. (Common.)
Rotalia Schrœteriana, P. & J.
Miliola (*Triloculina*); and others, indeterminable.

This group indicates a *late* Tertiary deposit.

EDITOR Q. J. G. S.

Notes on the PLATES XII. & XIII.

The Map, Plate XII. comprises a small Index-map of the North Island of New Zealand, and the central portion of a large Geological Sketch-map of Auckland and the surrounding district, constructed by Mr. C. Heaphy from actual survey in 1857, and corrected to February 1859.

The corrections here alluded to have arisen from observations made during the progress of Dr. F. Hochstetter's geological survey of the Auckland District.

It is expected that a more complete description of the volcanic and geological features of this and other parts of New Zealand will be supplied in the scientific publications of the Austrian "Novara" Expedition, by Dr. F. Hochstetter, the Geologist of the expedition, who remained in New Zealand, at the expense of the Provincial Government of Auckland, for the purpose of making a geological survey of the province.

In illustration of this memoir, the author has also supplied several original water-colour sketches, indicating the geological and volcanic

features of the district. These are preserved in the library of the Society, only one of them being now published.

Sketch No. 1, illustrative of the geology of the northern shore of Auckland Harbour, is here lithographed as Plate XIII., in which the different volcanic soils are indicated by lighter and darker tints.

Sketch No. 2 is a view of Manukau Harbour, from Pahakura, looking west. No. 3. Mount Richmond (No. 25 on the Map) and the neighbouring hills and craters. No. 4. Manukau Entrance. No. 5. Tarang'a, or "The Hen," and neighbouring rocks. No. 6. Barrack Hill and Mount Eden. No. 7. Castle Hill, Coromandel Harbour.—Editor Q. J. G. S.

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3. *On the* Geology *of a part of* South Australia *between* Adelaide *and the* River Murray. By T. Burr, Esq.

[The following is an abstract of the second of two Reports on the Geology of South Australia, by Mr. T. Burr, communicated by the Colonial Office in 1847 and 1848. In the first Report were described two sections traversing the country higher up to the north (one in the latitude of Mount Remarkable, 32° 44′ S.; and the other in that of the Burra Mines, 33° 41′). The chief points treated of in the Reports have been published in some detail in a little book entitled, "Remarks on the Geology and Mineralogy of South Australia," by Thomas Burr, Esq., Deputy-Surveyor-General of the Province: Adelaide, 1846.]

The lowlands about Adelaide on the west and along the River Murray on the east consist of horizontal beds of limestone and calcareo-siliceous deposits, yellowish and reddish in colour, full of marine fossils, and of Tertiary age. Sometimes gypsum and ferruginous sand replace the limestone. These plains are arid—except where granite protrudes from the surface, presenting cavities in which rain-water collects. The author observed a similar Tertiary formation on Yorke's Peninsula, at Port Lincoln, and to the S.E. to beyond Rivoli Bay; and it probably forms vast tracts in New South Wales and Western Australia. None of these Tertiary districts appear to exceed an elevation of 300 feet above the sea.

In describing two volcanos in South Australia, Mount Gambier and Mount Schanck, Mr. Burr remarked that, coming from the west or north-west, at about 20 miles from these hills a white "coral limestone" [Bryozoan limestone] containing flint or chert takes the place of the limestones and calcareous sandstones with recent sand-formation previously passed over. This white limestone is remarkable for the numerous deep, well-like water-holes in it, within about twelve miles of the volcanic mountains, and about east or west of them.

Mount Gambier has a height of 900 feet above the sea (600 feet above the plain), and has three craters lying nearly east and west and occupied with lakes of fresh water. Mount Schanck, at a distance of about nine miles magnetic south, is circular and has one large and two small lateral craters.

The author next described the granite, gneiss, and slaty rocks along a section extending from the River Murray and Kangaroo Range across Mount Barker and Mount Lofty towards Adelaide, and noticed the mode of occurrence of the ores of copper, iron, lead, &c., in these rocks. Lastly, he noticed and explained the occurrence of calcified stems of trees standing in the position of their growth in the sand-dunes of the Gulf of St. Vincent, near Adelaide.

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4. *On some* Tertiary Rocks *in the* Colony *of* South Australia. By the Rev. Julian E. Woods, F.G.S. *With Notes on the* Fossil Polyzoa *and* Foraminifera, by G. Busk, Esq., F.R.S., F.G.S., W. K. Parker, Esq., Mem. M.S., *and* T. Rupert Jones, Esq., F.G.S.

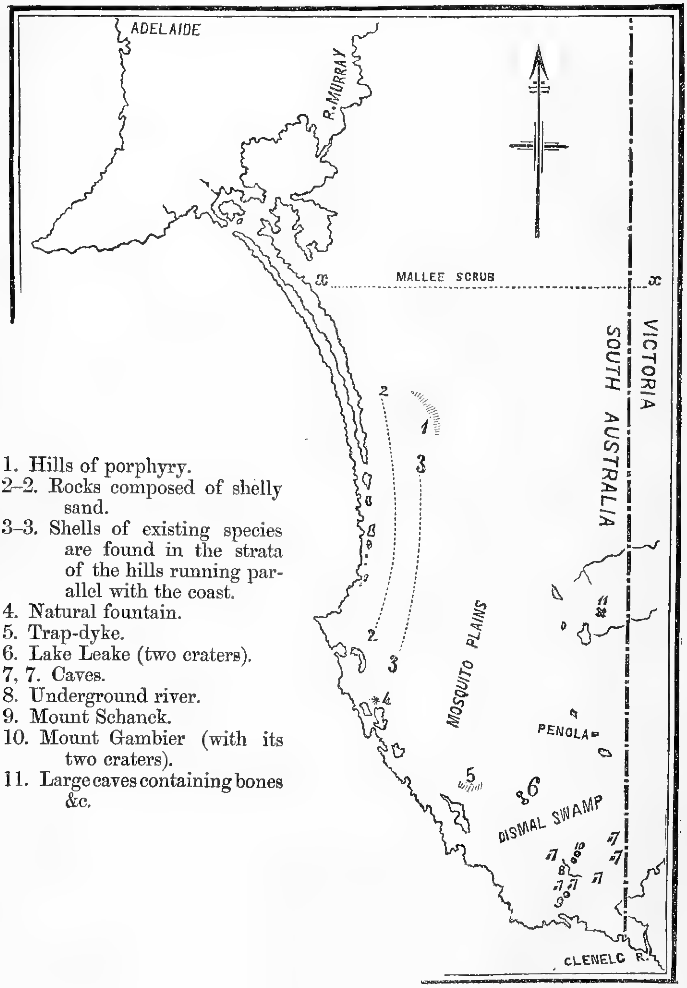
I propose to submit to the Society a description of an extensive Tertiary deposit in South Australia, which has never received more than a passing notice from any who have previously called attention to it. The beds to be described occupy so great a tract even of the large colony of South Australia, that they will, I am sure, eventually call forth a minute examination from those more competent than myself. If there were any probability of a geological survey of the place, under Government-auspices, I would not step forward to do what would then be better done in a much shorter time. But there is no probability of this. Victoria, alone, of all the Australian colonies, as far as I am aware, employs a geological surveyor; and of course he will not be permitted to extend his investigations far beyond the boundaries of that colony. As therefore there is no likelihood of any organized scientific inspection of the country I am about to describe, I venture to submit to the Society my own imperfect observations on facts which it may prove useful for science to be in possession of meanwhile.

The formation which is the subject of my observations extends westward and southward from the River Murray. The line *x x* across the map marks the northern boundary of the district with which I am acquainted (about 290 miles long, by an average breadth of 70 miles). This is all occupied with the tertiary limestone, excepting some small patches of post-tertiary deposits. A line of trap-rocks almost exactly follows the boundary-line of the two colonies; and then the tertiary beds reappear and continue to Port Fairy in Victoria, about 60 miles from the boundary.

The whole formation, and indeed the whole country laid down on the map, is remarkably level and horizontal throughout; the only exceptions being some few ridges, which never rise more than 200 feet above the plains, four extinct craters, and half a dozen hills raised by trap-dykes. The latter are in the southern portion of the district. In the north, on the edge of the Mallee Scrub (*Eucalyptus dumosa*), there are two or three ranges of porphyry rocks, forming chains of small eminences, some 50 feet in height, which run about east and

Sketch-map of a Part of South Australia.

[To illustrate the Rev. J. E. Woods's paper on the Tertiary Strata of that District.]



west for 100 miles, terminating in a volcanic district on the River Warmon, Victoria, about twenty miles over the boundary. With these exceptions the country is an immense plain, with a gradual rise from the sea. In the extreme south of the district are some extinct volcanos. To the north of these there lies an immense chain of swamps, the principal of which is called the Dismal Swamp—a large series of marshes about thirty miles long by ten broad. To the north of this again is a ridge of limestone (Tertiary), bordered on each side by swamps or sandy flats, to Penola, where the Mosquito Plains commence, and then continue right to the edge of the Mallee Scrub. No change of the level occurs as far as the Mallee is known. There can be no doubt that there is a continuation of the same flats, and most probably of the same formations, as far as the River Murray, a distance of 134 miles; but, as the scrub is nearly impenetrable from the tangled nature of the brushwood, and quite so for want of water, the geographical and geological features are not known. The cliffs of the Murray to the north are of the same description of rock as that found lower down near Penola. The Mosquito Plains are a series of swamps, which are shallower than those further north, and the water in them dries during the summer. This makes them available for pasturage, but the land is very inferior.

Before proceeding to describe the tertiary rocks, let me remark, in reference to the country, that there are two kinds of soil met with. The more common is a sand-peat, with stringy bark (*Eucalyptus Fabrorum*) and a fern (*Pteris esculenta*) as the only plants, besides the usual scrub-growth of Australia. The sand is found on examination to consist of rounded particles of pink felspar and white or transparent rounded grains of quartz, mixed with carbonate of lime and black loam. The other kind of soil is generally of a chocolate or black colour, with limestone-rock cropping out. It generally supports good grass and trees of the *Eucalyptus*, *Banksia*, and *Casuarina* class, besides many beautiful Acacias. Both these kinds of country pass into another; but, as a general rule, the sandy scrub is found on very level ground, and the well-grassed soil on that which is undulating. I shall now proceed to describe the formation which is universal in the district.

Immediately under the surface-soil, which is always of small depth, a white limestone is reached, of a compact texture, and containing no fossils. In some places it is only a few feet thick; in others, some twenty or thirty feet; and again in other localities it is entirely absent. Whenever caves are found, such as I shall hereafter have occasion to describe, they are always immediately under this non-fossiliferous bed; and where this is absent, I do not remember to have seen any caves.

Immediately under the bed which I have described come the fossiliferous limestone; but there is no abrupt line of demarcation between them, for the one passes insensibly into the other. This rock is composed of fragments of *Bryozoa*, sometimes so finely comminuted as only to show here and there small fragments of organic structure, imbedding occasionally the *Terebratula compta*, and fre-

quently the *Spatangus Forbesii*. At other places all organic traces are lost, and the rock appears like white chalk, of an extremely friable texture; or, again, the beds appear composed entirely of *Bryozoa*, huddled together in a very confused manner, but always forming strata. The most common fossils are the *Psileschara subsulcata* (nov. gen. et spec.), Busk, *Melicerita angustiloba* (sp. n.), Busk, *Cellepora Gambierensis* (sp. n.), Busk, which must have been, from its constant recurrence, the prevailing Bryozoan of the period, several *Escharæ*, *Celleporæ*, *Membraniporæ*, *Lepraliæ*, and other *Bryozoa*, of which a list has been drawn up by Prof. Busk, F.G.S., and appended to this paper. Two species of *Pecten* also, and some Echinoderms*, are not uncommon; and casts of Univalves also occur. The only fossil which I am able to identify as occurring in beds at home is the *Nautilus ziczac*, which is frequently met with. The specimens I have sent with this paper are not all equally abundant in the same strata,—some prevailing more in the lower, while others are more common in the upper beds.

In a spot near Mount Gambier, where the falling in of a large cave has given origin to a deep circular pit, about 100 feet wide and 90 deep, a complete section of the beds is exposed. It is here seen that, in addition to distinct lines of stratification which occur about every 14 feet, there are regular zones where particular fossils are associated. At the first bed (14 feet) little is seen but small *Bryozoa* with *Terebratulæ*. In the next (10 feet), less *Bryozoa* and some Bivalves. The next (12 feet) is almost exclusively composed of a species of *Pecten*, and the branched *Cellepora Gambierensis*. The beds seem to alternate thus to the water-line (there is water at the bottom of the pit), except that a *Retepora*? and the *Spatangus Forbesii* are more common lower down in the deposit.

I cannot assert that this arrangement is found throughout the district, but fossils are found in much the same way at the caves on the Mosquito Plains, seventy miles distant (marked on the accompanying map), where a fine section is exposed to view. It appears to me that the whole deposit has been formed in deep water, from the detritus of a large reef, which may have existed at some distance from the beds, as these appear to have been slowly spread out along the sea-bottom. This would appear from the chalky texture of the rock, which, when soft, must have been a white pasty mass, occasionally enclosing some fragmentary fossils which had escaped the general attrition. The large *Cellepora Gambierensis* is never in an upright position, but always broken and interstratified in the mass.

The general resemblance which the whole formation bears to the European Chalk is very singular. With the exception of well-defined strata and a rather more plentiful supply of fossils, the cliffs might easily be mistaken for chalk-cliffs; and then the usual sand-pipes (sometimes going to great depths) and rows of flints make the resemblance most striking. The flints just mentioned are generally black, occurring in regular layers, from 14 to 20 feet apart; and one layer

* *Eupatagus*, *Echinolampas*, and *Clypeaster*.—Ed.

is frequently found immediately over the water-level. Sometimes, however, the flints are white ; but this is seldom the case ; and both black and white varieties contain fossils, most commonly Bryozoans and Sponges.

It might naturally be expected that in such loose and soft deposits water would more or less undermine the rock and cause subterranean hollows. Accordingly we find that the whole district is more or less honeycombed with caves. Sixteen, and perhaps more, are known, of very considerable extent ; but the smaller ones abound in different localities, confined, however, to the higher ground, or where the country is undulating, for I cannot call to mind a single instance where they have been found on level flats. The most remarkable of all are those situated on a high ridge on the northern side of the Mosquito Plains (see Map, p. 254). There are three very close to one another, the entrance to which is a round aperture, about 6 feet wide, on the summit of the ridge on which they occur. The first cave is about 200 feet long, divided into three large halls, from which there are occasional passages leading into extensive side-chambers. At the end of the last cave the passage ramifies into several smaller tunnels, which, though too narrow to admit of actual examination, are supposed to be continued for a long distance. The direction of the caves is nearly north and south, that is parallel with the axes of the ridge. The entrance is at the southern end. At the termination of the first chamber in the large cave, there is a large stalactite, which almost entirely blocks up the passage into the next. At the foot of this, on the side of the entrance, there is a very extensive deposit of bones. These occupy just such a position as to lead one to conclude that they had been deposited from a current of water flowing from the entrance towards the narrow end. To such a stream the immense stalactite would act as a dam, only allowing the water to pass through a narrow passage at each side. I must state, however, that there is but slight internal evidence of such a stream, excepting perhaps that the walls of the cave are somewhat undermined all round the first chamber ; and a stream running strongly enough to bring down bones might be expected to leave more evident marks of its former existence. But, if a stream did hollow out the caves, there must have been a period during which its flow was stopped ; for the large stalactite bears evidence of having been formed in small columns at first, and a current of water would have prevented their formation, and have eroded them away much faster than the drippings from the limestone could repair the damage done. Supposing the great stalactite to have been formed during a time when water was not running, its existence easily accounts for the deposit of bones at its foot ; for it would act as a barrier to the stream.

The bones in question are mostly of extinct species, closely allied to those of animals at present inhabiting the locality, but many times larger. The most common are those of a rodent somewhat resembling, in the form of the skull, the dentition, and the markings on the molars, our existing domestic Mouse, though it is many times larger.

I have also identified the skull-bones of nine existing insectivorous Marsupials, and one Bat, all of the size of existing species. There is one thing more in this cave which deserves notice: it is the body of a native which lies in a crevice of one of the inner chambers. The remains are perfectly shrivelled and dry, and the skin tough like leather, broken through in some places and showing the bones underneath. It was partially imbedded in stalagmite some time since; but, having been moved by some settlers, there is no such appearance visible now. At first sight one would imagine the remains to be of great antiquity, but in reality they are very modern. It is only fourteen years since the man died in the spot where his body is now seen. He was shot in a quarrel between the settlers and aborigines, and was known to have crept to the place where he died, in order to escape pursuit. I cannot help thinking that the fact of human remains becoming almost fossilized by being imbedded in stalagmite is rather a valuable one. Dr. Lund, who found some bodies in a similar state in caves in South America, took from that circumstance the idea that the Indian race must have been in America much longer than we supposed. Would not the fact to which I am drawing attention modify the supposition of such immense age?

Close to this cave there are two more; neither of which, as far as I am aware, have ever been examined. One of them is 30 feet deep, and the other 60; and there is no means of descending into them without pulley and ropes, which are not easily procured in the unfrequented part of the Australian bush in which the caves are situated. Next in importance to the above are a series of caves in the vicinity of Mount Shanck, and between that and Mount Gambier. (The two most southerly craters marked on the map.) Some of them do not run very deep, but others have never yet been explored. They all resemble each other in one particular, and that is in the possession of water at a depth varying from 70 to 100 feet, dependent on the height of the eminence upon which they are. One is just like a round hole, about 100 feet in diameter; and the passage to the bottom is by a winding footpath to the water's edge, 75 feet below the surface. The cave then seems to shelve away to a great depth; but no more is positively known than that at about 10 feet from the side the soundings are 60 feet. At another cave very near this the descent is very sudden, so that the water stops further progress very near the entrance, and it is so deep as to appear of a deep sea-blue. The cavern is seen to continue in a fine arched passage, high above the water-level, to a distance far beyond what has ever been explored. In a cave at Mount Shanck the water is so deep that no bottom could be found with 120 feet of line. In every one of the above, and in many more that I have not described, the water is beautifully clear, and where deep of a sea-blue.

At certain seasons of the year (I have been informed) a distinct motion is perceptible; but I have been only able to verify this in one instance. This was at a short distance from Mount Gambier, where an extensive subterranean passage occurs. The opening to it is narrow and perpendicular, and from above the water is just discernible. Upon one

occasion a boat was lowered down to this, and a party of settlers floated along the surface for half a mile; and, though they then turned back, they alleged that the passage was as wide as ever and could have been followed to a much greater distance. On this body of water a distinct current is perceptible after the rainy season, and doubtless this is one of many underground rivers by which a large tract of country, unprovided with any other means of drainage, gets rid of its surface-water. This may be the cause of all the caves; but why they should always occur on the higher ranges and not upon the flats, does not appear very clear according to such a theory.

There are other facts which tend to show that some parts of the country are being drained by underground channels. Thus in certain localities on the Mosquito Plains all the wells are observed to have a distinct current to the north-west. Again, I noticed, in following the current of a large overflowing swamp, that the water disappeared at the foot of a limestone-ridge (in which there were only a few crevices) and became lost. Now at a place on the coast, N.W. of the Mosquito Plains (Lake Eliza, marked on the map), and at two places near the sea, south of the caves at Mount Gambier, natural fountains are found, where the water rises from holes in the rock in a fountain of some height, which must send up many gallons of water per minute. There may be many others which are not known, for the coast has been but little explored. At all events the existence of a chain of freshwater lakes along the coast, containing much more water than can be accounted for by the annual fall of rain, would seem to indicate an underground drainage; for it is known not to come along the surface. The channels made by the passage of this water will certainly become caves, should the land be hereafter sufficiently upheaved to leave them dry.

I have never been able to find bones in any caves but those of the Mosquito Plains, except in one or two shallow ones, where, though imbedded in stalagmite, they were all of existing species; and the aperture was always in such a position on the roof that animals, bounding across them, would be most likely to fall in. I met with one curious instance of how caves of this description might become full of animal remains. In exploring one near the coast, which had never been entered before, I crept along a gallery which led into a large chamber, in the centre of the roof of which there was a round hole about 2 feet wide. Underneath this was seen a large heap of Kangaroo bones; and skeletons were distributed about the chamber. On coming to the surface I found that the hole was almost perfectly concealed by grass, that an animal might jump into it without suspecting the existence of an aperture. Some might be killed immediately, and so leave their bones on the heap, while others would struggle about the chamber and leave their skeletons around.

I have now enumerated a few of the remarkable features of this extensive district, in which, though nearly 10,920 square-miles in extent, there are only one or two small patches where the deposit differs from the formation which I am led to believe is of an Eocene

character. These exceptions are,—first, a deposit composed of fine particles of sand and broken fragments of shells such as would arise from detritus brought along by a deep sea-current. The rock is stratified in a manner which fully bears out such a view. I believe that this formation covered nearly, if not quite, the whole of the limestone, but has afterwards been washed away by denudation, to which its friable texture would render it extremely liable. There is always more of it near the coast, and there in some places it is 200 feet thick. Elsewhere it is only in patches lying on elevated spots of ground, and apparently much water-worn.

A ridge of coarse limestone follows the line of coast; and in this, as well as in the limestone some few miles further inland, fossils abound; but they are all of species at present inhabiting the coast. This is the result of upheaval which appears from observation to continue to this day. It is worthy of notice that volcanic emanations occurred during the period of upheaval; and it would appear probable, from shocks of earthquakes that are occasionally felt, that the cause of them is yet in existence.

Note on the FOSSIL POLYZOA *collected by the* REV. J. E. WOODS *near* MOUNT GAMBIER, SOUTH AUSTRALIA. By GEORGE BUSK, Esq., F.R.S., F.G.S., &c.

The *Polyzoa* included in this collection belong to fifteen or sixteen genera, of which four are probably new; and the number of species is about thirty-nine or forty, of which at least thirty-six seem to be undescribed. Among them are several very peculiar and characteristic forms, especially in the genus *Cellepora*. Taken as a whole, these fossil forms exhibit such generic and specific types as to render it probable that the formation in which they are found corresponds, in point of relation to the existing state of things, with the Lower Crag of England, although the collection contains but one or two species which can be referred, and those even doubtfully, to any belonging to the Crag. It is remarkable, however, that it presents a second species of *Melicerita*, which genus is peculiar to that deposit. Of the characteristic *Fasciculariæ* and other *Theonidæ* of the Crag no trace exists in the present collection. The most characteristic form is a large and massive *Cellepora*, for which I propose the name *Cellepora Gambierensis*.

List of Genera and Species.

I. P. CHEILOSTOMATA.

1. Salicornaria, *Cuvier*.
    1. S. sinuosa, *Hassall*.
    2. S. Parkeri, n. sp.
2. Canda, *Lamx*.
    1. C. angulata, n. sp.
3. Onchopora, *Busk*.
    1. O. pustulosa, n. sp.
4. Membranipora, *Blainville*.
    1. M. stenostoma, *Busk*. ?
    2. M. bidens, *Hag*.

3. M. appressa, n. sp.
4. M. Cyclops, *Busk.*

5. Lepralia, *Johnston.*
1. L. ——, sp.?
2. L. submarginata, n. sp.
3. L. subcarinata, n. sp.
4. L. doliiformis, n. sp.

6. Cellepora, *O. Fabr.*
1. C. Gambierensis, n. sp.
2. C. hemisphærica, n. sp.
3. C. nummularia, n. sp.
4. C. costata, n. sp.
5. C. tubulosa, n. sp.
6. C. spongiosa, n. sp.?

7. Eschara, *Linn.*
1. E. simplex, n. sp.
2. E. papillata, n. sp.
3. E. arcuata, n. sp.
4. E. oculata, n. sp.
5. E. bimarginata, n. sp.
6. E. hastigera, n. sp.
7. E. inornata, n. sp.
8. E. ——, sp.?

8. Retepora, *Imperato.*
1. R. ——, sp.?

9. Psileschara, nov. gen.
1. P. pustulosa, n. sp.
2. P. subsulcata, n. sp.

10. Cœleschara, nov. gen.
1. C. australis, n. sp.

11. Melicerita, *M.-Edwards.*
1. M. angustiloba, n. sp.

12. Scutularia, nov. gen.
1. S. prima, n. sp.

II. P. CYCLOSTOMATA.

1. Pustulopora, *Blainville.*
1. P. distans, n. sp.

2. Idmonea, *Lamx.*
1. I. Milneana, *D'Orbigny.*
?2. I. ligulata, n. sp.

3. Hornera, *Lamx.*
1. H. Gambierensis, n. sp.?
2. H. rugulosa, n. sp.?

Note on the FORAMINIFERA *from the* BRYOZOAN LIMESTONE *near* MOUNT GAMBIER, SOUTH AUSTRALIA. By W. K. PARKER, Esq., and T. RUPERT JONES, F.G.S.

A small portion of the deposit has yielded several *Foraminifera*, namely,—

Polymorphina lactea, *J. & W.* Rather large. }
Textularia pygmæa, *D'Orb.* Small. } Not rare.
—— agglutinans, *D'Orb.* Small. }
Globigerina bulloides, *D'Orb.* Small. Common.
Cassidulina oblonga, *Reuss.* Small. Rather common.
Rosalina Berthelotiana, *D'Orb.* (a variety of *Rotalia Turbo*, D'Orb.). Small. Rather common.
Rotalia Ungeriana, *D'Orb.* Rather large. Abundant. }
—— Haidingerii, *D'Orb.* Small. Not uncommon. } Varieties of *Rotalia (Planorbulina) farcta*, F. & M.
—— reticulata, *Czjeck.* Small. Not rare. }
—— (Anomalina) Rotula, *D'Orb.* Small. Rare. }

The above-named Rhizopods exist at the present day, and for the most part live in rather deep water, at from 200 to 300 fathoms. It would hence appear that the fragmentary *Bryozoa* forming the mass of the deposit were washed down from a higher zone of sea-bottom and mingled with the *Foraminifera* inhabiting deep water.

December 14, 1859.

John Holmes Bass, Esq., 2 Picton Villas, Holloway, was elected a Fellow.

The following communications were read:—

1. *Note on* some Remains *of* Polyptychodon *from* Dorking. By Prof. Owen, F.R.S., F.G.S., &c.

[Abstract.]

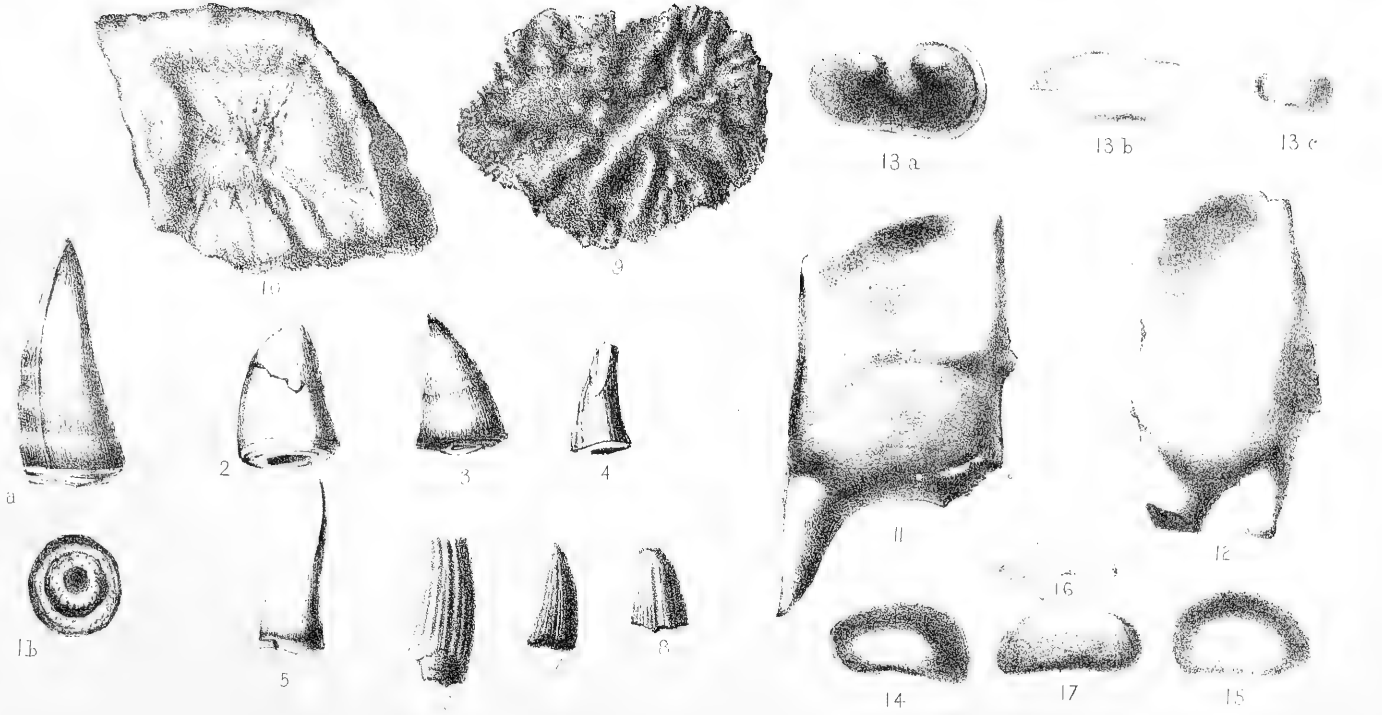
Referring to the genus of Saurians which he had founded, in 1841, on certain large detached teeth from the Cretaceous beds of Kent and Sussex, and which genus, in reference to the many-ridged or folded character of the enamel of those teeth, he had proposed to call *Polyptychodon*, Professor Owen noticed the successive discoveries of portions of jaws, one showing the thecodont implantation of those teeth, which, with the shape and proportions of the teeth, led him to suspect the crocodilian affinities of *Polyptychodon*; and the subsequent discovery of bones in a Lower Greensand quarry at Hythe, which, on the hypothesis of their having belonged to *Polyptychodon*, had led him to suspect that the genus conformed to the plesiosauroid type. The fossils now exhibited by Mr. G. Cubitt consisted of part of the cranium, with fragments of the upper and lower jaws and teeth of the *Polyptychodon interruptus*, from the Lower Chalk at Dorking, and afforded further evidence of the plesiosauroid affinities of the genus.

The cranial fragment included the frontal, parietal, and mastoid bones; and at the overlapping suture between the frontal and parietal was situated a large oblique 'foramen parietale'—a part not present in the order *Crocodilia*, but characterizing the corresponding region of the cranium in the Plesiosauroids,—the 'foramen parietale' being likewise present in many Lacertians, in the Dicynodonts, the Ichthyosaurs, and Labyrinthodonts.

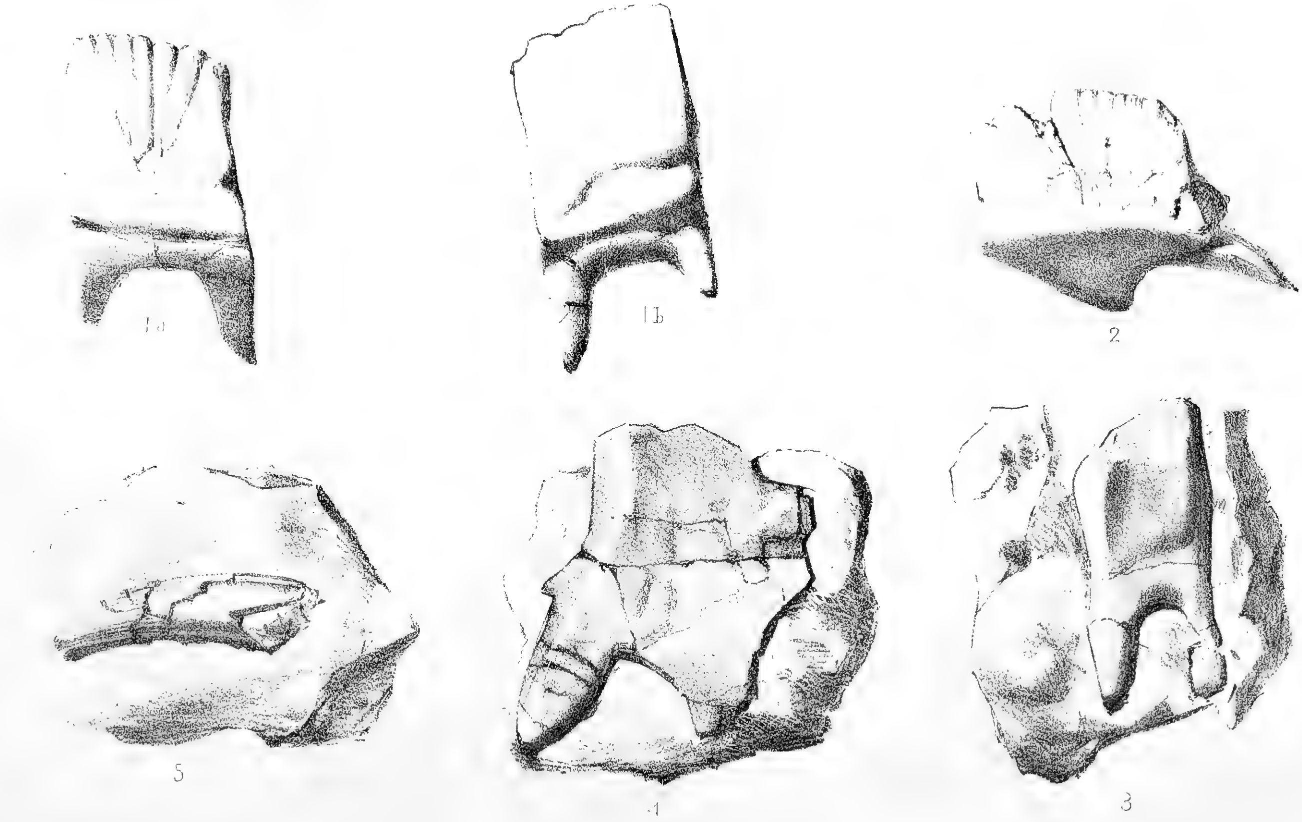
The temporal fossæ were large, and met upon the upper part of the parietal, with the intervention of a sharp and high ridge. The nasal bone was narrow, and transversely convex above. Other particulars of the cranial structure were specified.

Professor Owen further remarked, that, in a collection of fossils from the Upper Greensand near Cambridge, now in the Woodwardian Museum, and in another collection of fossils from the Greensand at Kursk, Russia, submitted to the Professor's examination by their discoverer, Colonel Kiprianoff, there were teeth of *Polyptychodon*, with plesiosauroid vertebræ of the same proportional magnitude. In the Cambridge series, one of these vertebræ, from the cervical region, presented the flattened articular surfaces, and the single transverse process for a simple-headed rib, on each side, closely according with the plesiosauroid type. The length of this vertebra was 4 inches 3 lines; the breadth across the articular surface was 5 inches 3 lines; the total breadth, including the transverse processes, was 7 inches.

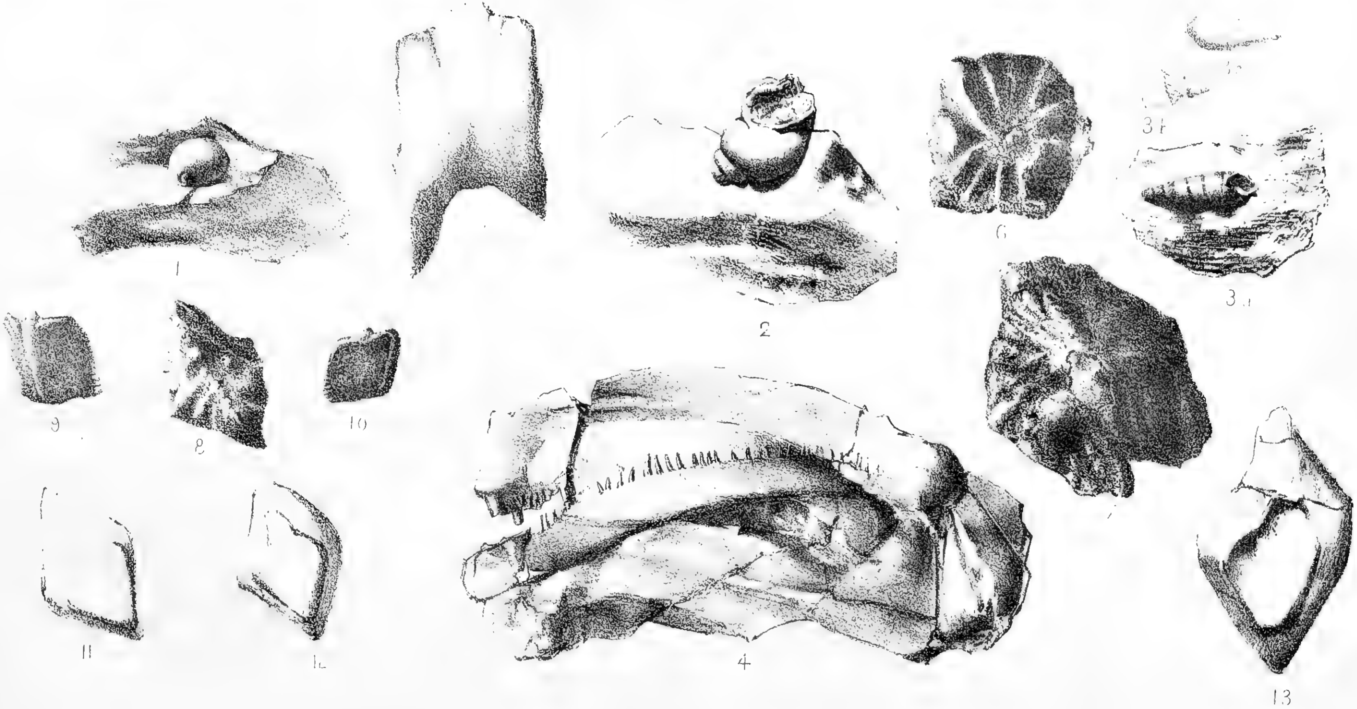
Fossils from Buhu.



Fossils from Bahia.



Fossils from Bahia.



Fossils from Bahia

One of the vertebræ from Kursk, belonging to the dorsal region, showing the two venous foramina at the under surface, with other plesiosauroid characters, measured 4 inches in length, and 5 inches 4 lines across the flat articular surface. No other teeth from the Russian Greensand agreed in proportionate size with these vertebræ, save those of *Polyptychodon*. Portions of large limb-bones, without medullary cavity and of plesiosauroid shape, from the Greensand beds of Cambridgeshire and Russia, were also believed by Professor Owen to belong to the *Polyptychodon*; and he was now led to refer to the same genus the large Plesiosauroid paddle, from the Chalk of Kent, the phalanges of which were figured in his 'History of British Fossil Reptiles,' Part v. pl. 30, and in the 'Monograph on the Fossil Reptilia of the Cretaceous Formations' (Palæont. Soc.), pl. 17. Thus the evidence at present obtained respecting the huge but hitherto problematical carnivorous Saurian of the Cretaceous period, seemed to prove it to be a marine one—the rival and contemporary of the equally huge Maestricht lizard. But whilst the *Mosasaurus*, by its vertebral, palatal, and dental characters, seemed to foreshadow the saurian type to follow, the *Polyptychodon* adhered more closely to the prevailing type of the sea-lizards of the great geological epoch then drawing to its close.

Professor Owen also exhibited drawings showing the mode and degree of use or abrasion to which the teeth of *Polyptychodon* had been subject.

One of these teeth, in the collection of W. Harris, Esq., F.G.S., from a chalky deposit with greenish granules, in a tunnel of the railway near Frome, Somerset, showed the apical half of the crown smoothly worn away, and presenting a flattened surface continued obliquely a little way upon one side of the crown.

Another tooth, from the Cambridge Greensand, measuring 1½ inch across the base, showed, with abrasion of a great part of the crown, a smooth, slightly concave channel extending from the crown to the fang, and apparently formed by the gnashing action of an opposite large tooth.

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2. *On the Discovery of some* Fossil Remains *near* Bahia *in* South America. By S. Allport, Esq.

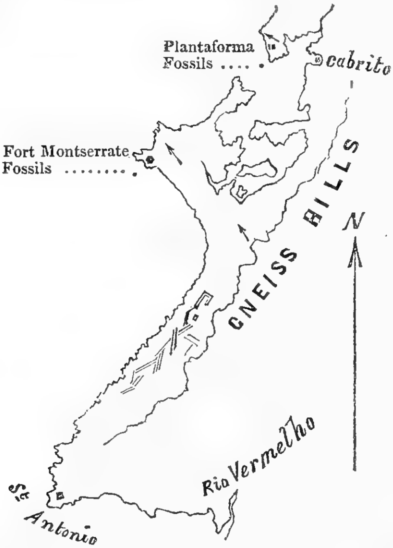
[Communicated by John Morris, Esq., F.G.S.]

[Plates XIV.–XVII.]

On referring to a map of Bahia, it will be seen that a line of hills runs from the Point of St. Antonio in a north-easterly direction. They form for some distance steep rocky cliffs, skirting the Bay, and continue in the same direction for several miles. They also form the seaward exposed edge of an elevated range of country, and present a steep slope to the N.W.; and are everywhere covered by red loam or sand, except where exposed to the action of the sea. These are gneissose rocks, usually exhibiting distinct lines of strati-

fication or foliation, but not unfrequently passing into amorphous masses (see Map, fig. 1).

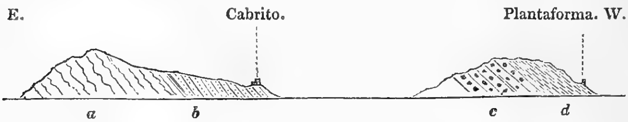
Fig. 1.—*Sketch-map of a part of the vicinity of Bahia.*



The direction of the general line of upheaval clearly coincides with that of the above range of hills, being N.E. and S.W.; the dip of the gneiss, where it can be well made out, being always to the N.W.

In Itapagipe Bay, near Cabrito, there is a white sandstone, interstratified with shale, the dip of which is also to the N.W. It forms a low hill, running nearly parallel with the gneiss hills, at a distance from the latter of three or four hundred yards in the direction of

Fig. 2.—*Section across the Gneiss Hills north of Bahia.*



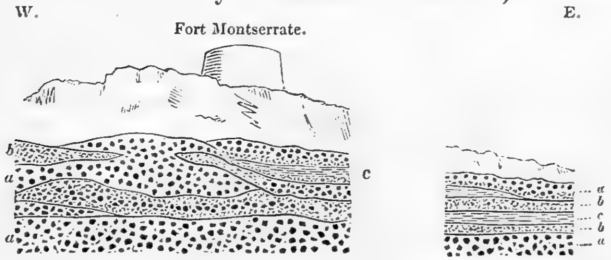
a. Gneiss. *b.* Sandstone and shale. *c.* Conglomerate. *d.* Fossiliferous shale.

the dip (fig. 2). No organic remains have yet been discovered here; but this deposit has not been carefully examined.

At a distance of about two miles from the gneissose range, and running parallel with it, is the isolated hill of Montserrate (see Map, fig. 1), which extends for nearly a mile in length, and ranges in height from about 25 to 150 feet. The rocky cliff forming the

S.W. point of the hill on which the fort of Montserrate is built presents to view several alternations of conglomerate, sandstone, and shale (see Section, fig. 3). Towards the N.E., these beds pass into

Fig. 3.—*Section of the Cliff at Montserrate.* (The detached Section is about 25 yards eastward of the Fort.)



a. Conglomerate. *b.* Sandstone. *c.* Sandy shale, with fossils.

a gritty shale, of a bluish-grey colour, and full of pebbles; the latter gradually disappear, and the upper strata, as far as the seaward exposed portion extends, consists of beds of shale, alternating with bands of sandstone, both of which contain the same species of fossil shells. The entire series of these deposits are covered with the usual red loam, and have the general inclination to the N.W.

The seaward exposed portion of the cliff of Montserrate, about 30 feet in height, consists chiefly of conglomerate, with irregular wedge-shaped bands of shale and clay, and also bands of sandstone. The conglomerate is composed of more or less rounded pebbles of gneiss, granite, quartz, and other crystalline rocks, and occasionally of sandstone; the whole forming an extremely hard rock. The pebbles vary in size from the finest gravel to large boulders.

In the shale near the base of the cliff were found the fossils about to be noticed (see Plates XIV. XVI. & XVII.), consisting chiefly of scales and other portions of Fish, bones and teeth of Saurians, together with Lignite, a few *Mollusca*, and some *Entomostraca*.

Two miles from the above hill, in a N.E. direction, is the Plantaforma (see fig. 1 and fig. 2), another hill of the same formation, but loftier; the conglomerates and shales have here the same lithological character, and in the latter are found several fossils (Plate XV.) similar to those found at Montserrate.

The geological position of the above formations is undetermined, as they have not been traced in connexion with other deposits; but a probable inference may perhaps be made from an examination of the fossil remains.

Notes on the Fossils *from* Bahia.

With regard to the Fish-remains, Sir P. Egerton, Bart., F.G.S., to whom the specimens have been submitted, states that "the scales are those of *Lepidotus*. The species appears to be a new one. The

nearest approach to it is an undescribed species from the Lithographic stone of Pappenheim."

Numerous fish-bones were found associated with the scales; and probably the greater portion belong to *Lepidotus* also. But these and the Crocodilian teeth and bones, which are also common in these clays from Montserrate and Plantaforma, have not yet been systematically examined.

Professor Owen, on a cursory view of the large vertebra figured in Pl. XVII., suggested that it would prove to be a dorsal vertebra of a Dinosaurian Reptile allied to the *Megalosaurus*.

Note on the Molluscan Remains *from* Montserrate. By John Morris, F.G.S.

The fossil shells, from the greenish sandy clay, from Montserrate are—A cast of a bivalve (1 in. by $1\frac{1}{2}$ in.) apparently belonging to the genus *Unio*; a smooth-shelled *Neritina* (rare); numerous small *Paludinæ*; and several specimens of a larger *Paludina*, having a smooth shell, subumbilicate, and showing four ventricose whorls, deeply sutured; also several individuals of an apparently new species of *Melania*, which may be defined as follows:—

Melania terebriformis, spec. nov. Pl. XIV. figs. 3 *a*, 3 *b*, 3 *c*.

Shell subulate, consisting of 7–8 flattened whorls, marked with numerous oblique, somewhat prominent, rounded ribs, which are in some specimens stronger towards the anterior part of the shell. In some individuals the posterior part of each whorl is slightly raised, making the suture more distinct. The last whorl is somewhat constricted. The aperture is ovate. The lip of the columella is somewhat thickened and reflexed.

Fig. 3 *c* is a smooth variety, with a less cylindrical shell.

Note on the Fossil Entomostraca *from* Montserrate. By T. Rupert Jones, Esq., F.G.S.

About seven or eight specimens only of Entomostracan valves, not well preserved, are to be seen on the fragments of green clay, containing small *Paludinæ*, from Montserrate, submitted to examination. The hinges of the valves are not exposed; and other important features are obscure. The following appear to be distinct forms, as far as the shape of the carapace-valves can serve as means of judging.

1. Cypris (?) conculcata, spec. nov. Pl. XVI. figs. 13 *a*, 13 *b*, 13 *c*.

Carapace suboblong, slightly incurved on the dorsal and ventral borders, rounded at the ends, narrowest behind; greatest convexity of the sides at the posterior third. Surface of the valves smooth, slightly margined (this, however, may possibly be due to pressure in this specimen), and markedly pinched in at the middle of the dorsal region, where there is a broad shallow sulcus with a slight swelling before and another behind it.

This somewhat reminds us both of *Cypris gibba*, Ramdohr*, and of *Cytherideis unicornis*, Jones†, in their young state before the anterior and posterior tubercles of the dorsal furrow have been developed into spines. Fig. 13 *c* is a smaller, smooth, oblong carapace, probably the young of *C. conculcata* above described.

2. Candona candida, Müller, sp. Pl. XVI. fig. 14.

Cypris candida, Müller, Entom. p. 62, pl. 6. figs. 7–9; *Candona lucens*, Baird. Hist. Brit. Entom. p. 160, pl. 19. fig. 1; *Candona candida*, Jones, Monog. Test. Entom. p. 19, pl. 1. fig. 8.

Judging from the imperfect materials at command, it is not possible to separate this fossil Cyprid of Montserrate from Müller's species above indicated.

3. Cypris (?) Montserratensis, spec. nov. Pl. XVI. fig. 15.

Carapace having an outline somewhat like that of the blade of a cheese-knife, strongly arched (nearly semicircular) on the back, straight on the ventral border; bluntly curved at one end, obliquely curved at the other; the greatest convexity of the sides is on the medial third and ventrade.

In shape, this somewhat approaches *Cypris compressa*, Baird, and *C. Browniana*, Jones.

4. Cypris (?) Allportiana, spec. nov. Pl. XVI. fig. 16.

Carapace long and narrow, subcylindrical, arched on the back; extremities tapering, obtuse, one rather more acute than the other.

This has a form rare among the *Cyprides*, and, as a *Cypris*, comparable only with *C. clavata*, Baird. Amongst marine Entomostracans we might more readily find resemblances as to outline; as its associates, however, were apparently fluviatile or lacustrine (or at most of brackish-water habits), it is preferable to keep the Cypridal relationship of this small unique specimen prominent.

The name of the discoverer of the freshwater deposits of Montserrate and Plantaforma is associated with this species; and it is to be hoped that further research by himself or his friends will supply us with more abundant materials.

5. Cypris (?). Pl. XVI. fig. 17.

This suboblong, slightly curved carapace has resemblances in its shape to so many *Cyprides* and *Candonæ*, that, without the aid of other distinctive characters, it would be vain to regard it as determinable.

The generic relations of these *Entomostraca* are doubtful, except in the case of the *Candona candida*; and here we are guided merely by the shape of the carapace. Fig. 13, though having an analogue among the *Cyprides*, may be a *Cythere* or *Cytherideis* (such as often

* Jones, Monog. Test. Entom. p. 15, pl. 1. fig. 3.

† Mem. Geol. Surv. Gt. Brit. (Tert. Isle of Wight), 1856, p. 158, pl. 7. figs. 24–26.

live in brackish water). The others may be all *Candonæ*, and of freshwater habits.

It is to the recent and tertiary species that the above-described *Cypridæ* appear to be allied, as far as the foregoing observations are concerned.

EXPLANATION OF PLATES XIV.–XVII.

Plate XIV.

Fig. 1. *Neritina.*	Montserrate.
2. *Paludina.*	
3 *a.* *Melania terebriformis*, spec. nov.	
3 *b.* ,, ,, portion magnified.	
3 *c.* ,, ,, another specimen (Smooth var.).	
4. Jaw and teeth of a fish. Plantaforma.	
5–8. Scales of *Lepidotus*, with radiate sculpture.	Montserrate.
9–13. Smooth scales of *Lepidotus*.	

Plate XV.

Fig. 1 *a*, 1 *b*, 2, 3, 4. Scales of *Lepidotus*, with radiate sculpture.	Plantaforma.
5. Tooth of Crocodile, with coarse riblets.	

Plate XVI.

Fig. 1 *a*, 1 *b*, 2, 3, 5. Teeth of Crocodile, with delicately wrinkled surface.	Montserrate.
4, 6, 7, 8. Teeth of Crocodile, with strong continuous striæ and coarse riblets.	
9. Sculptured bone of Crocodile.	
10, 11, 12. Scales of *Lepidotus*, with granulate ornament. (Figs. 11 & 12 show the smooth under side.)	
13 *a.* *Cypris* (?) *conculcata*, spec. nov. Right valve.	
13 *b.* ,, ,, Back view.	
13 *c.* ,, ,, Young. Right valve.	
14. *Candona candida*, Müller.	
15. *Cypris* (?) *Monteserratensis*, spec. nov.	
16. *Cypris* (?) *Allportiana*, spec. nov.	
17. *Cypris* (?).	

Plate XVII.

Fig. 1, 2. Lateral views of a Dorsal Vertebra of a Dinosaurian Reptile. (Half natural size.)	Montserrate.
3. Outline of end view of the same. (Natural size.)	
4. Outline of side view of the same. (Natural size.)	

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3. *On a* Terrestrial Mollusk, *a* Chilognathous Myriapod, *and some* New Species *of* Reptiles, *from the* Coal-Formation *of* Nova Scotia. By J. W. Dawson, LL.D., F.G.S., Principal of M'Gill College, Montreal.

On revisiting the South Joggins in the past summer, principally with the view of collecting material for the further prosecution of my researches on the structure of coal, I was informed by Mr. Boggs, the superintendent of the mine at that place, that a second erect tree had been exposed by the wasting of the cliff, in the bed which had afforded to Sir Charles Lyell and the writer in 1851 a fossil stump

containing the remains of *Dendrerpeton Acadianum* and other terrestrial animals*. I at once proceeded to the place, and found, still *in situ* in the ledge at the base of the cliff, the lower part of an erect trunk, about fifteen inches in diameter, and much more richly stored with animal remains than that previously found. It was carefully removed from the rock, and all the fragments containing fossils carried off for examination. They contain numerous specimens of the land-shell found in the tree previously discovered in this bed; several individuals of an articulated animal, which I believe to be a Myriapod; portions of two skeletons of *Dendrerpeton*, and of seven small skeletons belonging to another Reptilian genus, and probably to three species. I propose in the present paper to notice the mode of occurrence of the remains in this curious repository, to describe the invertebrate animals contained in it, and to state shortly the characters of the new Reptilian species.

§ 1. *Mode of occurrence of the Fossils.*—The reptiliferous tree of 1851 had fallen from the cliff before it was examined; and though, by putting together the fragments, it was possible to form a pretty correct idea of their original arrangement, this could not be ascertained with positive certainty. In the present specimen, the arrangement of the materials filling the cavity of the stump could be distinctly observed, and corresponded perfectly with that inferred in 1851. The trunk was enclosed, as usual, in a cylinder of carbonized bark, and was indistinctly ribbed in the manner of *Sigillaria*. It was rooted in arenaceous shale or fine argillaceous sandstone, immediately over the six-inch coal in group No. XV. of my section of the South Joggins coal-measures†; and had extended upward into the overlying sandstone, but the upper part had been removed by the sea. The bottom of the trunk was floored with a thin layer of carbonized bark. On this rested a bed of fragments of mineral charcoal, about an inch in thickness, being probably the fallen remains of the woody axis of the trunk. On microscopic examination, this mineral charcoal displays elongated wood-cells, some of them with the pores or discs in several rows, as in many Sigillaroid trees. Imbedded in the upper part of the layer of charcoal were a few reptilian bones; and among the charcoal was coiled up a *Sternbergia*-cast, perhaps of the pith of the tree. Above the charcoal, the trunk was occupied, to a height of about six inches, with a hard, black, laminated material, consisting of fine sand and carbonized vegetable matter cemented by carbonate of lime. In this occurred the greater part of the animal remains, along with many fragments of plants, principally leaves of *Naeggerathia* (*Poacites*), *Carpolites*, and *Calamites*, also many small pieces of mineral charcoal, showing the structures of *Lepidodendron*, *Stigmaria*, and the leaf-stalks of Ferns. The upper part of this carbonaceous mass alternated with fine grey sandstone, which filled the remainder of the trunk as far as seen.

The animal remains must have been introduced at intervals, in the earlier part of the filling of the hollow stump, and the scattered

* Proc. Geol. Soc. 1852, Quart. Journ. Geol. Soc. vol. ix. p. 58.

† Quart. Journ. Geol. Soc. vol. x. p. 20.

condition of the bones indicates that the soft parts had time to decay before the specimens were buried by the addition of new layers of vegetable matter and sediment. I account for these appearances, by supposing that this tree, like other erect *Sigillariæ* in this section, became hollow by decay, after being more or less buried in sediment; but that, unlike most others, it remained hollow for some time in the soil of a forest, receiving merely small quantities of earthy and vegetable matter, falling into it, or washed in by rains. While in this condition it may have served as a place of shelter to the animals found in it, or may have been too deep to permit their escape when they fell in by accident. Possibly it was a place of residence for the snails and myriapods, and a trap and tomb for the reptiles; though the coprolitic matter in some of the layers would seem to indicate that these last in some instances were able to subsist for a time in this underground prison. The occurrence of so many skeletons, with probably more than a hundred specimens of land-snails and myriapods, in a cylinder only fifteen inches in diameter, proves that these creatures were by no means rare in the coal-forests, though they have left so few indications of their presence in other beds. The existence of vertical hollow stumps in such a condition that air-breathing creatures could reside in or fall into them, implies that the soils of the Sigillarian forests were not always so low and wet as we are apt to imagine.

§ 2. *Carboniferous Land-Snail—Pupa vetusta*, n. s. (Figs. 1–3.)

An imperfect specimen of this shell, found in 1851, was described by Sir C. Lyell, and its structure figured, in the Quart. Journ. Geol. Soc. vol. ix. pl. 4. The numerous specimens which I now possess enable me to present a complete restoration of its form, and to state that it falls within the limits of the genus *Pupa*. It may be described as follows:—

Cylindrical, but tapering towards the apex; surface shining, minutely marked with longitudinal rounded ridges; whorls eight or nine, rounded, width of each whorl about half the diameter of the shell; aperture rather longer than broad; outer lip regularly rounded and reflected at the margin; pillar-lip straightish above, rounded below. Edentulous; length $\frac{3}{10}$ths of an inch, or a little more.

I obtained in all about fifty specimens more or less complete of this shell from the interior of this trunk, and many others must remain concealed in the matrix. There were also numerous fragments of shells that had been broken and partially decomposed, as if this hollow stump had long served as a harbour for land-snails. It is very probable that they formed a part of the food of their reptilian associates, and some may have been introduced by them. I have found in the stomach of a specimen of *Menobranchus lateralis* not six inches in length, as many as eleven unbroken shells of *Physa heterostropha*. The coal-reptiles and batrachians may have devoured their contemporary pulmonates in similar quantity.

Where so many examples of one species of pulmoniferous mollusk

occurred, I was disappointed in finding no indications of any other. Two specimens of a minute discoidal shell, which I at first supposed to be molluscous, proved to be merely examples of the little *Spirorbis* so common in the coal-measures of the Joggins. These may have formed part of the food of the smaller reptiles, or may have been drifted in, attached to the vegetable fragments. In neither case would the occurrence of these shells imply access of salt water to the deposit; as I have good evidence from other parts of the section that this little shell, though apparently a *Spirorbis*, and allied to, if not identical with, the *Spirorbis* or *Microconchus carbonarius* of the British coal-measures, was not an inhabitant of the sea, but rather of fresh and brackish water.

Figs. 1–3.—Pupa vetusta *from the Coal-measures of Nova Scotia.*

Fig. 1.

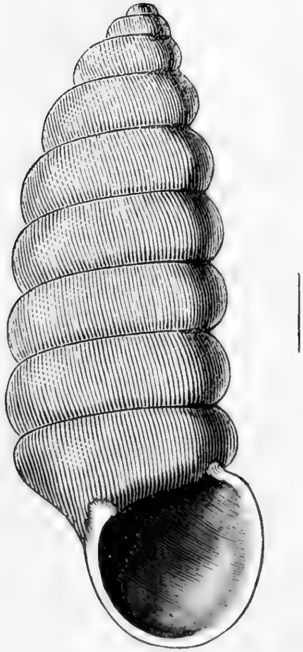

Fig. 2.

Fig. 3.

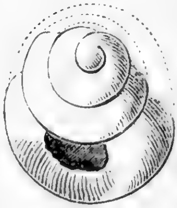

Fig. 1. Magnified specimen. The natural size is indicated by the vertical line at the side. 2. Ridges, magnified. 3. Apex, magnified.

§ 3. *Carboniferous Myriapod—Xylobius Sigillariæ*, n. g. et sp. (Figs. 4–9.)

I propose the above name for an articulated worm-like animal, of which numerous flattened specimens were found associated with the *Pupa vetusta*. I was at first disposed to regard it as the larva of a

coleopterous insect; but a careful microscopic examination of the specimens convinces me that it is a chilognathous Myriapod, allied to *Iulus*. It may be described as follows:—

Body crustaceous, elongate, articulate, when recent cylindrical or nearly so, rolling spirally. Feet small, numerous; segments 30 or more; anterior segments smooth, posterior with transverse wrinkles, giving a furrowed appearance. In some specimens traces of a series of lateral pores or stigmata. Labrum? quadrilateral, divided by notches or joints into three portions. Mandibles two-jointed, last joint ovate and pointed. Eyes ten or more on each side.

I have endeavoured, in figs. 4–9, to represent these characters as they appear in several specimens. They leave no room to doubt

Figs. 4–9.—Xylobius Sigillariæ *from the Coal-measures of Nova Scotia.*

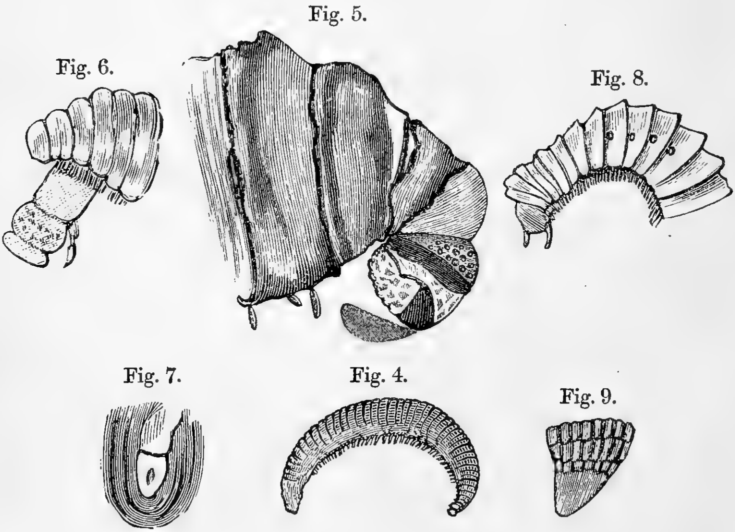

Fig. 4. Specimen of the natural size. 5. The head, magnified; showing the eyes. 6. The labrum (?), magnified. 7. The mandible (?), magnified. 8. The anterior part of the body, magnified; showing the lateral pores. 9. The posterior part of the body, magnified; showing the longitudinal ridges.

the affinities of the creature; but I have not the means of comparison with the various genera into which the *Chilognatha* have been divided by some modern authors. For this reason, in the hope that some one who has made these animals a special subject of study will institute such comparison, I send several of my best specimens with this paper.

The *Xylobius Sigillariæ* must have burrowed among the vegetable

matter in the interior of the trunk in which it was found; and the specimens were probably crushed and buried by the sand with which it subsequently became filled. The occurrence of such a creature is another evidence of the similarity of the conditions of the areas of coal-accumulation to those of modern forests. The oldest Myriapod previously known is, I believe, the *Geophilus proavus*, Münster, of the Jurassic period *.

§ 4. *Reptilian Remains.*

The number of specimens entombed in this singular repository is so great, and the bones so much scattered, that it will require much skill and care to work out all their relations. In the mean time I desire merely to describe and figure such parts as may serve distinctly to characterize the several species †.

The *Dendrerpeton Acadianum* is represented by portions of two skeletons, belonging to individuals of different sizes. In addition to the parts formerly described by Professors Wyman and Owen, my specimens exhibit the greater part of the cranial bones, perfect examples of the lower jaws and teeth, vertebræ, ribs, and phalanges. We learn from these that the whole surface of the cranium and jaws was strongly sculptured. There appears to have been a double occipital condyle. The orbits were very large. The teeth were in two series; the outer were simple, conical, and either straight or curved,

Figs. 10–13.—Dendrerpeton Acadianum *from the Coal-measures of Nova Scotia.*

Fig. 11. Fig. 10. Fig. 12. Fig. 13.

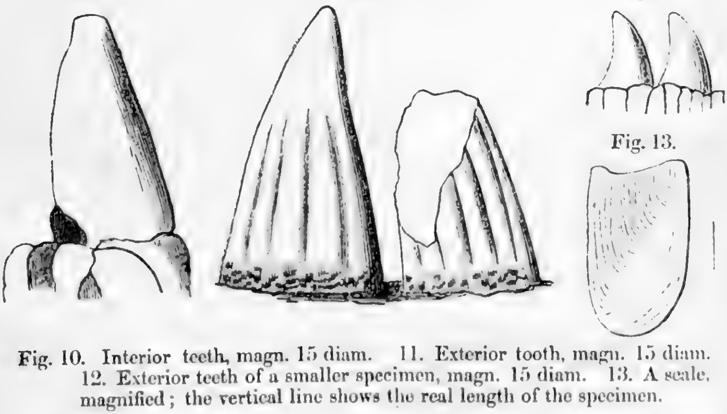

Fig. 10. Interior teeth, magn. 15 diam. 11. Exterior tooth, magn. 15 diam. 12. Exterior teeth of a smaller specimen, magn. 15 diam. 13. A scale, magnified; the vertical line shows the real length of the specimen.

the inner larger and furrowed longitudinally by the corrugated plates of dentine (figs. 10–13). There are also indications of a group of

* Pictet, Paléontologie, vol. ii. p. 405.

† Besides the figures given in the woodcuts, the author has sent several drawings of Reptilian remains, very carefully executed by Mr. H. S. Smith, Artist to the Canadian Geological Survey.

teeth on the vomer. The centres of the vertebræ are ossified, but biconcave, and the spinal processes large and flattened. The ribs are short in proportion to the size of the animal. The bones of the limbs are short and stout. The body was covered with broad and thin scales, the usual form and sculpturing of which I have endeavoured to represent in fig. 13. These structures are evidently much in advance of those of *Archegosaurus* and other genera included in the Order *Ganocephala* of Owen, and indicate affinities rather with the *Labyrinthodontia*. The bones of the legs and feet also, though scattered and only in part observed, indicate adaptation for walking rather than swimming.

Hylonomus, gen. nov.

The other reptilian remains represent three species belonging to a generic form which, so far as I am aware, has not been previously observed, and for which, in allusion to its forest habitat, I propose the above name. As its typical species I shall describe that of which some remains are represented in figs. 14–18, and which I

Figs. 14–18.—Hylonomus Lyellii *from the Coal-measures of Nova Scotia.*

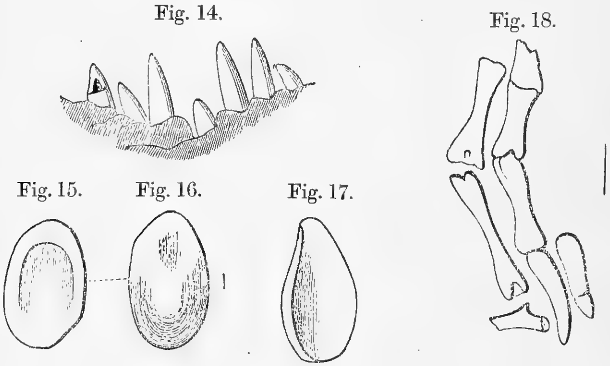

Fig. 14. Teeth, magn. 15 diam. 15, 16, 17. Scales, magnified; the vertical line shows the real length. 18. Phalanges, magnified; nat. length shown by the straight line.

would name *Hylonomus Lyelli*. Its cranial bones are thin and smooth; the condyle I have not been able to observe, but there is a parietal foramen, and the parietal bones are arched in such a manner as to indicate a rounded rather than flattened skull, and a somewhat capacious brain-case. Its teeth are numerous (about 26 in each maxillary bone), elongated, conical, closely set in a single series, in a furrow protected externally by an elevated alveolar ridge. In the intermaxillaries and extremities of the mandibles the teeth are larger than elsewhere. Fig. 14 represents a portion of the teeth of the maxillary bone as exposed by the fracture of the outer ridge. The vertebræ are imperfectly preserved, but appear to have been ossified, biconcave, and with well-developed spinous processes. The ribs are

long and curved; and there are traces of numerous accessory pieces which have been attached to their extremities. Only one sacral vertebra can be made out, and it has broad lateral apophyses. The pelvis is of large size and remarkable form; the ilium long and expanded below, the ischium greatly expanded; the pubis expanded and triangular where it joins the ischium, and round and arched toward the symphysis. The femur is thick and nearly straight, the tibia short and stout, the fibula slender, the phalanges broad. The hind limb thus largely developed must have been capable of supporting the whole weight of the body in standing or leaping. The anterior extremities appear to have been comparatively slender, with thin and long fingers. A few scattered vertebræ lying posteriorly to the pelvis may, perhaps, be remains of a tail. There was a dermal covering of small ovate bony scales, of which, however, only a few scattered specimens remain (figs. 15, 16).

This species is evidently quite remote from the ganocephalous and labyrinthodont types of Batrachians, and in many respects approaches to Lacertians. It may perhaps be allied to the *Telerpeton* of Elgin, but does not appear to resemble any reptile hitherto found in the coal-formation. Three skeletons of this species appear to have been entombed in the erect *Sigillaria* in question. The most perfect of

Figs. 19–23.—Hylonomus aciedentatus *from the Coal-measures of Nova Scotia.*

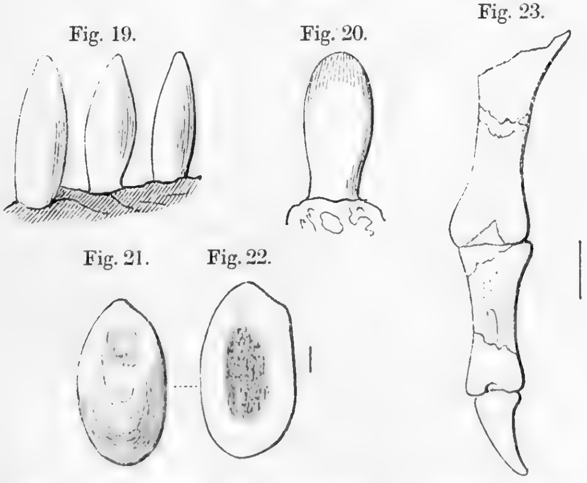

Fig. 19. Teeth, magn. 15 diam. 20. Inner tooth, magn. 15 diam. 21, 22. Scales, magnified. 23. Phalanges, magnified. The nat. length is shown by the straight line.

these is that represented in Mr. H. S. Smith's drawing, fig. 3. Pl. III.* The fragment of a jaw in fig. 14 is from a second; and a number of

* Not engraved.

the bones of a third are contained in a specimen which I have sent with this paper, for presentation to the museum of the Society.

A second species is represented by scattered bones belonging to two individuals. In general form and structure it must have resembled that above described, but it was twice as large, and its teeth are much more numerous (about 80 in each jaw), and they are flattened and expanded toward their summits (fig. 19). It is also possible that there was a second series implanted on the palate or pharynx, as I have found a few teeth of the form represented in fig. 22, cylindrical, with blunt striated summits. These do not resemble any of the teeth of *Dendrerpeton*, and are more likely to have belonged to this than to either of the other species of *Hylonomus*. There is also a bone which seems to be a sphenoid, having on its anterior part a number of conical tubercles that seem to have supported slender teeth. A foot of one individual is well preserved, and with some other characteristic bones is represented in fig. 1, Pl. III.* A magnified view of one of the toes is given in fig. 23. The dermal scales of this species are similar to those of that last described, but are a little larger (figs. 20, 21). I propose for this species the name of *Hylonomus aciedentatus*.

A third species, much smaller than either of the former, is represented by bones belonging to at least two individuals. Its teeth number about 22 in the lower jaw, alternately large and small, conical but obtuse (fig. 24). Its vertebræ are elongated, and the

Figs. 24–26.—Hylonomus Wymani *from the Coal-measures of Nova Scotia.*

Fig. 24.

Fig. 25.

Fig. 26.

Fig. 24. Teeth, magn. 15 diam. Figs. 25, 26. Scales. The nat. size is shown by the vertical line.

conical cavities at their ends coalesce in the middle of each vertebra, the centrum having thus been cartilaginous in its interior. In one series of these vertebræ, there are as many as 26 joints. Only traces of ribs are seen; they seem to have been long, but very slender. The feet of one individual are well preserved, and have four toes. Its scales are like those of the other species, but very small and thin (figs. 25, 26). The small vertebræ found by Prof. Wyman in the contents of the former reptiliferous tree, and described in the paper above cited, must have belonged to this species. For this reason I propose for it the name of *Hylonomus Wymani*. I hope ere long to be able to place the whole collection in the hands of that able comparative anatomist, that the farther details of their structure and affinities may be more fully worked out.

* Not engraved.

A very interesting portion of this collection is a quantity of carbonized skin, which must have belonged to one of these reptiles, probably to the last-mentioned species. It is smooth and shining, and in part still contains the imbricated bony scales, which it covers as in modern lizards, projecting a little beyond their edges. In one place, probably at the occiput or shoulders, it contains a transverse row of broad, striated bony plates, behind which are some projecting bony tubercles. This part of the skin, which is as perfect as if taken from a recent specimen, is represented in fig. 13, Pl. II.* Other portions of it appear scaleless, with minute pores or punctures; and attached to it are a number of pointed lobes or processes covered with minute ovate scales, each having a puncture in the centre. These must have been large and ornate cutaneous appendages, similar to those on the back and gular pouch of the Iguanas, unless they were swimming-lobes like those on the tail of the Crocodiles, or, which seems less likely, branchial processes like those of some perennibranchiate Batrachians.

Besides the more perfect bones above referred to, there are some small patches of broken bones, probably of *Hylonomus Wymani*, which have the appearance of being coprolitic; but in the distinct masses of coprolite, I have seen no distinguishable remains except those of *Xylobius*, or some similar Articulate.

I may perhaps be permitted to add to this paper a notice of a remarkable tooth found several years since by Sir W. E. Logan in

Figs. 27–29.—*Batrachian (?) Tooth from the Coal-measures of Nova Scotia.* (In the Collection of Sir W. E. Logan.)

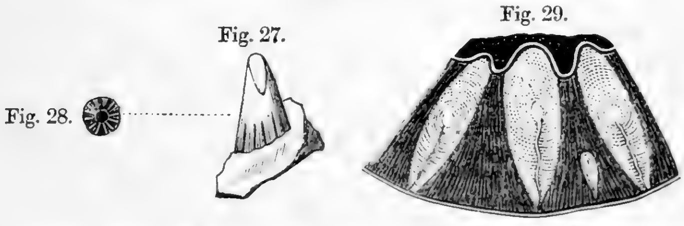

Fig. 27. The tooth of the natural size. Fig. 28. Cross section, nat. size. Fig. 29. Part of the cross section, magnified.

one of the bituminous limestones of the Joggins, and which may indicate the existence there of another labyrinthodont reptile of large size, though it is also possible that it may have belonged to a sauroid fish. It is represented of the natural size in fig. 27, and the structure of its dentine, which is beautifully preserved, in fig. 29. It has been broken, both at the base and at the summit, before it was enclosed in the rock.

* Not engraved. The tubercles mentioned above are not represented in the figure. They occur almost immediately in front of the large scales, and resemble the shorter bony tubercles of some species of *Phrynosoma*.

4. *On the Occurrence of* Footsteps *of* Cheirotherium *in the* Upper Keuper *in* Warwickshire.

By the Rev. P. B. Brodie, M.A., F.G.S.

The occurrence of certain footprints of *supposed* Labyrinthodont animals in the Upper Keuper in the neighbourhood of Warwick has been long known; and they generally consist of a series of small casts and impressions, chiefly the former, over a considerable extent of surface; but no larger footsteps have been before noticed in the district. These were obtained from Shrewley and Rowington, where the Keuper contains also remains of Fish and Plants, though not exactly in the same bed affording the footmarks.

The specimen to which I now wish to draw the Society's attention was met with in a ploughed field, lying loose on the surface, having been evidently turned up by the plough, of which it bears the marks, in an extension of the same sandstone at Witley Green near Preston Bagot, about a mile from Henley in Arden, where it occupies high and undulating ground, the surface of which has been much denuded. The district is traversed by a N. and S. line of fault. (See Geol. Survey Map, sheet 54 N.E.) The sandstone crops out in a lane adjacent, and might easily be quarried; but I searched in vain for any other large slabs likely to contain any footprints, although no doubt they might be discovered along the same horizon if the stratum containing them were worked. The specimen (of which I have sent a reduced photograph) consists of two casts in relief on the under surface of a slab of sandstone, 1 foot long and 9 inches broad, of the large hind and the smaller fore foot. The breadth of the hind foot, from the thumb to the fourth toe, is $4\frac{1}{2}$ inches; the extreme length, from the second toe (the longest) to the heel, is 4 inches. The cast of the front foot is very indistinct and lies in advance, in close juxtaposition to the hind foot. It measures about 2 inches across; and the length, as far as an approximation can be made, is about $1\frac{1}{2}$ inch. As the sandstone of Cheshire, so well known for its fine and numerous impressions of *Cheirotherium*, belongs to the upper part of the New Red series, it may be concluded that it is of the same age as the Upper Keuper of Warwickshire; which conclusion is strengthened by the presence of the *Cheirotherium*, although this is the first indication of any large footprints of animals which have been called by this name in the latter county.

The specimen above referred to is now deposited in the Warwick Museum, which contains the finest collection of fossils from the New Red Sandstone (Upper and Lower Keuper) in the kingdom.

January 4, 1860.

Stephen Harlowe Harlowe, Esq., 2 North Bank, St. John's Wood; The Rev. S. W. King, Saxlingham Rectory, near Norwich; and David Llewellin, Esq., C.E., Glyn Neath, Glamorganshire, were elected Fellows.

The following communications were read:—

1. *On the* Flora *of the* Silurian, Devonian, *and* Lower Carboniferous Formations. By Prof. H. R. Goeppert, For. M.G.S.

(In a letter to Sir Roderick Murchison, F.R.S., F.G.S., dated Breslau, Oct. 31, 1859.)

While thanking you for your valuable work 'Siluria,' which you have had the kindness to send me, I have the honour of announcing to you that I have completed my work on the 'Flora of the Silurian, Devonian, and Lower Carboniferous Formations.' It is already printed, and will be published at the expense of the Imperial Academy of Naturalists at Jena, accompanied by twelve lithographic and photographic plates*.

The number of all the fossil plants in the said formations amounts to 185 species. They are distributed (*a*) according to the orders or natural families, thus:—

Algæ	30	species.
Calamineæ	20	,,
Asterophylliteæ	4	,,
Filices	65	,,
Selagineæ	40	,,
Cladoxyleæ	4	,,
Nœggerathieæ	8	,,
Sigillarieæ	6	,,
Coniferæ	6	,,
Fruits (incertæ sedis)	2	,,
	185	,,

(*b*) According to the different formations.

I. *Silurian Formation* (Murchison).

1. Lower Silurian formation	17	species.
2. Upper Silurian formation	3	,,
These all belong to the *Algæ*.	20	,,

II. *Devonian Formation* (Murchison).

1. Lower Devonian .... 6 species.

Five of these belong to the *Algæ*; one to terrestrial plants—*Sigil-*

* See Nova Acta Acad. Cæsar. Leop.-Carol. Germanic. Nat. Curios. vol. xxvii. pp. 425, &c.—Ed.

laria Hausmanni, Goepp., found by M. Hausmann in 1807 (Reise in Scandinavien, vol. v.; Kjerulf, Geolog. der südlichen Norwegens, p. 87) near Idre and Särne. It is perhaps the most interesting plant of the whole work.

2. Middle Devonian .... 1 species.

One terrestrial plant, *Sagenaria Weltheimiana,* from the schist of Hamilton County, New York; but you and M. Verneuil consider that these beds belong to the Upper Devonian formation, in which, in Silesia, Thuringia, Ireland, and in the so-called Chemung? and Catskill formations of the State of New York, a much larger number of terrestrial plants has been found, amongst which this species of *Sagenaria* also occurs.

3. Upper Devonian .... 57 species.

This formation contains fifty-seven species, of which seven belong to the *Algæ*; the others are terrestrial, and belong to the families which are found up to the close of the Palæozoic period, viz. the *Ferns, Calamineæ, Equisetaceæ, Lepidodendreæ, Lycopodiaceæ, Sigillarieæ, Coniferæ,* and *Nœggerathieæ.* The Devonian flora comes in here with four species, the "Culm" flora with the same number, and the flora of the "youngest grauwacke" (Murchison) with seven species.

III. *Carboniferous Formation.*

Here we must distinguish a *lower* and an *upper* Carboniferous formation, the floræ of which are different.

1. Lower Carboniferous .... 108 species.

In regard to the flora, this is very different from the Upper Carboniferous formation. It contains the flora of the Mountain-limestone (Bergkalk or Kohlenkalk), the flora of the "Culm," and of the "youngest grauwacke" (Murchison).

a. The flora of the Mountain-limestone or Kohlenkalk contains forty-seven species—one *Alga* and forty-six terrestrial plants, which belong to the same families as occur in the Upper Devonian formation.

b. The flora of the "Culm" (Kulmgrauwacke, inclusive of the Posidonomyenschiefer) contains twenty-three species, of which four belong also to the flora of the "youngest grauwacke." Only one marine plant occurs; the others are terrestrial.

c. The flora of the Grauwacke ("youngest grauwacke" of Murchison) contains fifty-one species (all terrestrial), of which only seven have been found in the Upper Carboniferous formation*. One single species, *Neuropteris Loshii,* has been found in the Mountain-lime-

* Professor Goeppert (in Nova Acta, *loc. cit.*) gives 814 as the number of vegetable species known to him in the Upper Carboniferous formation, and 182 for those of the Permian, making altogether 1181 Palæozoic species of plants. —Ed.

stone, Culm, Grauwacke, Upper Carboniferous formation, and the Permian formation (Murchison).

Observe:—(*a.*) All these portions of the flora of the Lower Carboniferous formation have a very great affinity with each other, and all contain three remarkable species (*Calamites transitionis*, *C. Rœmeri*, and *Sagenaria Weltheimiana* [*Knorria imbricata*]), which truly deserve to be called "Leitpflanzen" (characteristic plants).

(*b.*) The genus *Knorria*, Sternb., ought no longer to exist. It is only a form of the genus *Sagenaria* or *Lepidodendron*, and the most common species, *Knorria imbricata*, belongs to *Sagenaria Weltheimiana*.

(*c.*) *Stigmaria ficoides* is in reality a *rhizoma* of *Sigillaria*. I possess a great number of different degrees of development of this remarkable plant, which ought to be figured and published, but at present I do not know whence they have come.

Some time ago I had the honour of sending you a memoir entitled "Die angeblich in der Grauwacke vorhandenen Kohlenlager," &c. ("The Coal-deposits supposed to exist in the Grauwacke"), in which I announced the locality whence I had obtained specimens of *Pterygotus Anglicus* with the *Graptolites*, the first found in Germany.

I have to request that you will have the kindness to communicate all these observations to the Geological Society, of which I have the honour to be a Foreign Member.

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2. *On the* FRESHWATER DEPOSITS *of* BESSARABIA, MOLDAVIA, WALLACHIA, *and* BULGARIA. By Captain T. SPRATT, R.N., C.B., F.R.S., F.G.S.

IN some brief papers recently published in the Society's Journal*, I have drawn the attention of geologists to the freshwater deposits which so extensively form the margin of the Grecian Archipelago and the Sea of Marmora.

I have also stated, that they seem to me to be connected with similar freshwater deposits which I have described as existing in the southern part of the Dobrutcha†, between Baljik and Kustenjeh; and with others bordering different parts of the Black Sea, such as those noticed by Hamilton in the valley of the Halys near Sinope; and by Pallas, De Hell, and others at Kertch, Taganrok, and Odessa. All these give fragmentary indications of a great Oriental Lake having extended over the area of the Grecian Archipelago, the Black Sea, and Sea of Azof.

From recent observations made whilst employed within the Delta of the Danube and the adjacent lakes, I am enabled to state that large portions of the southern parts of Bessarabia, Moldavia, and

* Quart. Journ. Geol. Soc. vol. xiv. p. 212.
† Ibid. vol. xiii. p. 77; and vol. xiv. p. 203.

Wallachia, reaching apparently to the foot of the Carpathian mountains, are composed of lacustrine deposits, purely of freshwater origin; although, from their containing a peculiar striated bivalve like a *Cardium*, and from the mistaking of a large fossil *Dreissena* for a *Mytilus*, by some early travellers, some portions of these deposits have been considered to be indicative of brackish water conditions; there having thus been an apparent admixture of marine with the freshwater shells of these strata.

Although I thought there was an error regarding the so-called *Mytilus*, since I had seen the large-sized *Dreissena*, much resembling a *Mytilus*, in the gravel or drift-deposits of Gallipoli and Rodosto, I had for a long time no means of solving the doubtful point either in its case or in that of its associate, the apparently marine *Cardium*; for, notwithstanding many dredgings made in different parts of the Black Sea during the late war, I never could discover either of these bivalves, or their representatives, living in its water, although a true *Mytilus* is the most common living shell in the Black Sea.

When carrying out my researches on the shores of the Danube, however, I observed numerous valves of a shell resembling this apparently marine *Cardium*, cast up together with marine and freshwater shells, near every embouchure of the river; and, notwithstanding that my research was renewed on this account, no living specimen could be obtained from the brackish waters of the adjacent parts of the Black Sea. The conclusion to which I then came, in consequence, was that the loose valves must either be fossils, and had been carried out by the Danube from some of the deposits bordering it, or that they were living either in some brackish lagoon within the Delta, or in the river itself.

The survey of the lakes of Kattabug and Yalpuk following soon after, I then discovered that these shells were abundant within them; the mollusc to which they belong living there as a really freshwater bivalve in depths of 5 and 6 feet and more; and I then saw that the animal differed from the true marine *Cardium* in having two elongated siphons.

It was thus rendered more probable that the Cardium-like shell in question is truly a freshwater bivalve, which had existed in, and descended from, the great Oriental Lake period; probably, however, with some slight modification of character, since it seems to me to be nearly identical with one of the so-called Cardiums found in the Kertch deposits; and with the one in the gravel at Gallipoli in the Dardanelles, where it is associated with the *Mytilus polymorphus* of some authors, the *Dreissena* of modern conchologists.

It is important to make these preliminary remarks whilst contemplating the freshwater deposits of the southern parts of Moldavia and Bessarabia, and of the Dobrutcha, in which apparently the same bivalve is abundantly found, in order to remove the impression which might exist, of its being a *Cardium* that has by a gradual transition from a marine to a brackish, and finally to a freshwater medium, become habituated to the latter as its natural element. From my own observations I am inclined to view it as being originally a purely

freshwater creation, as much as the *Unio* or the *Dreissena*, its present associates. But this is a point for the naturalist to determine; my superficial views and acquirements merely permitting me, and with all deference, thus to state my opinions, which are the grounds for the conclusions arrived at in the following detailed description of the deposits bordering the Danube, and which I hence regard as of a purely freshwater, and not of a brackish water origin. And I may be permitted, perhaps, to plead for indulgence relative to any error I may have committed on this head, from not having it in my power to refer to works of modern geologists bearing upon it, more especially of Professor Abich, who may have already published a similar conclusion from researches in other localities prior to, or subsequent to, mine made in 1856 and 1857 at the Danube.

The southern bounds of the Danubian Valley below Widdin is remarkable for rather abrupt and high land; whilst on the north, the Wallachian, Moldavian, and Bessarabian area rises in such a gentle slope, that it appears to the eye, in many parts, a dead level for miles, constituting the Steppe. But nevertheless, it is found to be slightly undulating, and to increase in elevation as we recede from the Danube. It is also traversed by several well-marked, although shallow, valleys, which near the sea-coast, or the Delta of the Danube, terminate in long brackish lagoons, or freshwater lakes, bordered by old sea-cliffs, or steep embankments, which exhibit some sections of the strata constituting the "Steppe-deposits."

These deposits seem to be divisible into three distinct series; although in reality there may be only two,—namely, 1st, a lower group of marly strata, whitish, grey, and brown, with indurated layers of sandstone and marl. 2nd. A middle group of softer marls, with fossils differing, for the most part, from those in the former, and in general more closely resembling the shells living in the existing lakes. It is possible, however, that these two series are not distinct in geological time, or unconformable. They may be more developed towards the extremity and lower parts of the Steppe than in the upper portion, where they may have formerly existed, but have been since denuded, having had a greater elevation, and consequently been subjected more readily to the violent degrading effects of some subsequent disturbance in the condition and limits of the old lake, whereby the group No. 3 was originated. This is probably a drift-series. Its deposits are apparently more earthy than those of Nos. 1 and 2, and contain in their lower part some bands of drifted fossils, which seem to have been gathered together by their gravity at the cessation of the troubled condition that produced the drift, and denuded the older lake-deposits. This drift, or deposit formed between the lacustrine and the present period, filling the hollows in the denuded surface over a wide extent of the lacustrine area, has given its smooth and level character to the Steppe.

It is not clear to me that the apparently troubled and turbid waters depositing this drift were as purely fresh as the waters of the lake at earlier periods; for there are certain facts which lead to the

inference that these deposits are impregnated with salts, either of mineral or marine origin:—such as the uncertainty of obtaining drinkable water from wells sunk in many parts of the Steppe; also the growth, in some localities, of certain saline plants from which an alkali is obtained; the fact also that only certain trees will flourish on that part of the Steppe where the earthy marls of the drift alone form the surface. Several mineral-springs also, of considerable medical repute, I believe, are known to exist in the Principalities.

This saline property may, however, not be due to purely marine salts, but to some mineral solutions that were set free from volcanic or other subterranean sources during the final destruction of the great Oriental Lake, the existence of which is identified by groups No. 1 and No. 2. The existence of this old lake, therefore, may be said to be traceable to a period immediately before the present Black and Caspian Seas changed from fresh to salt.

This superficial drift, indicating the presence of saline matters, may indeed be the result of depositions that occurred during that transition-period, and thus may indicate that during that event there was a sudden admixture of a large body of sea-water with the lake, which probably, I think, rapidly subsided to the level of the Mediterranean, being now brought into connexion with it by the opening of the Bosphorus, brought about by the general volcanic disturbance that apparently then took place. For great upheavals must have occurred about this period, as shown at Baljik by the high elevation at which the corresponding freshwater deposits and relics of the drift are now found, namely, about 600 feet above the sea. From this height they gradually incline towards the valley of the Danube, or rather towards the north,—just as the Bessarabian deposits gradually incline towards the south. But the lake may probably at the latter period of its existence have stood at a much higher level than the present sea, as conjectured in former papers.

If this be the true explanation in respect to the origin of the superficial deposits or drift, then the body of sea-water thus suddenly thrown into the lake must have come from the north, by the uprising of some large portion of Russia, as has before been conjectured by some of our most eminent geologists in accounting for the origin of the drift;—that is, on the supposition that the superficial earthy marls constituting group No. 3 of the Steppe-series is a real drift, or a deposit formed during the change of the lake into a brackish or salt sea; and I have seen no recent deposit, either as a member of the superficial marls or otherwise, that indicates, by evidence of fossil shells, a long tranquil period of brackish water conditions.

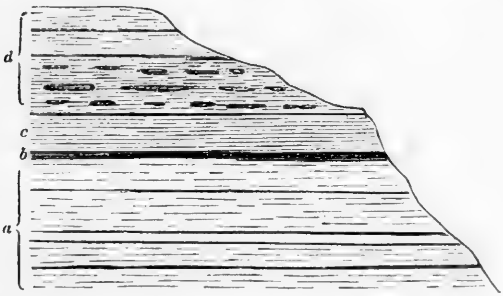
I lean also to the opinion that the lake was not long at a higher level with brackish water, or in a transitional state, from the fact that a communication apparently existed about this time between the Black Sea and the Sea of Marmora by the Buyuk Tchekmejeh Valley, which is, I believe, nowhere more than a few feet above the present level of the Black Sea, and consists of a chain of lakes, marshes, and alluvial soil.

I must apologize for commencing my remarks with such speculations; but, as the contemporary freshwater deposits of other localities have been made familiar to the Society by my recent papers, I am induced to keep these ideas prominent whilst the South Russian deposits are being noticed.

As the shores of the Yalpuk Lake present the best sections for the study of the Steppe-deposits, I shall here give two or three sections from its cliffs and banks; first mentioning, however, that, as the Steppe-deposits have a very gradual incline from north to south, it is only towards the head of this and the other lakes, and at distances of from fifteen to twenty miles from the Danube, that the lower group of freshwater deposits (No. 1 of the series) appears visible above the level of the lake. The extremity of the Steppe at the southern part of these lakes is composed of the upper and newer groups of loose marls, in which there is a change of character and less evidence of stratification.

The following section (fig. 1) was taken on the west side of the Yalpuk Lake, two or three miles below Bolgrod; it shows about 100 feet of the lower group of freshwater strata, No. 1.

Fig. 1.—*Section of the Steppe Deposits near Bolgrod.*



d. 40 feet of yellow, brown, and grey sands and sandy marls, closely interstratified with detached bands or slabs of indurated sandstone. The whole contains casts of freshwater shells, and selenite.

c. 8 feet of marly sandstone, containing freshwater shells.

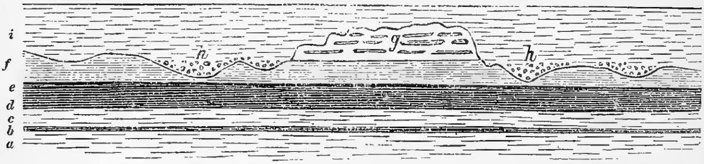
b. 1 to 2 feet of black peaty marl, overlaid by a band of marl, about 1 foot thick, with numerous freshwater shells.

a. 40 to 50 feet of sands and marls, containing beds with the same freshwater shells; and with two species of the striated bivalves (small *Cardium*) scattered through the whole group: but the flattish bivalve is the most numerous*.

* The specimens of fossil shells sent by Capt. Spratt from this locality have

Section fig. 2 is also taken from the west side of the lake, but a few miles lower down, near the village of Inputsitza.

Fig. 2.—*Section of the Steppe Deposits near Inputsitza.*



a is a stratum, about 12 feet thick, of grey sandy marl. The striated bivalves (*Cardium* or *Didacna*) found in the lower group of freshwater strata are abundantly dispersed through it, having their valves closed. In the upper part there is a very fossiliferous bed, about 1 foot thick, containing *Unio*, *Planorbis*, *Paludina* (large and small), *Melanopsis* (two species, large and small, and both smooth), also a *Limnæa* (*L. peregra*, apparently) and *Neritina*.

b. A bed of black peaty marl, with lignite and impressions of leaves and weed. At its base is a thin stratum of ferruginous sandstone, with a thin band of ochre-like clay beneath.

c. 6 feet of yellow sandy marl, with a few of the same fossils as those in *a*.

d is a bed of dark peaty marl, 5 feet thick.

e. A band of black peat; 6 inches.

f. Dark peaty marl, 10 feet thick, with freshwater shells. The fossils occur chiefly in a bed about 1 foot thick.

g. A fragment of the sands and indurated sandstones shown in *d* of section, fig. 1, near Bolgrod. It is similarly composed of detached bands of gypseous sandstone and indurated sandy marl, with casts of freshwater fossils upon them. Both *g* and *f* have been subjected to considerable degradation or denudation before

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been examined by S. P. Woodward, Esq., F.G.S., who has kindly supplied the following list:—

Fossil shells from the Lower Freshwater Deposits of Bessarabia from near Bolgrod, Moldavia.

Paludina vivipara ?
——, young, of a more ventricose form.
Valvata, sp.
Rissoa ? exigua, *Eichw.* ? ; shell imperforate.
—— Triton, *Eichw.* ?; shell umbilicate.
Hydrobia ? Conus, *Eichw.* ? ; slender, 3 lines long.
Melanopsis acicularis, *Fér.*
Neritina fluviatilis.
——, sp.
Planorbis corneus.
Limnæa peregra.
Cardium (Didacna).
Dreissena polymorpha.
——, sp.

Fossil shells from the Upper Freshwater Series at the South end of Lake Yalpuk.

Paludina vivipara ? ; with flattened whorls.
Unio pictorum.
Cardium (Didacna) crassum.

being covered by the superficial earthy marls (*h*, *i*), and in some parts are entirely wanting. The debris of *f* and *g* is sometimes found in the lower part of the overlying deposits (*h*, *i*); and appear as groups of shells from *f*, and fragments of the sandstones from *g*, collected together in the hollows formed by the denuding action.

According to this evidence, therefore, the deposits *h* and *i* belong to No. 3, the superficial series or drift, which here directly overlies No. 1, or the lower freshwater series, represented by *a*—*g*.

Further southward, and on the point above Inputsitza, occurs a cliff, about 25 feet high, composed wholly of the stratum *g* of the Section fig. 2; the subjacent beds being below the level of the lake. Here the overlying beds of the upper series are also somewhat gravelly, being the rounded fragments of the indurated layers in *g*.

Below Inputsitza the above group of deposits entirely disappear; and a loose marly series occurs, which I have designated as No. 2 (p. 283), from its containing some distinct fossils, as well as differently characterized strata. No good section was seen showing these marls in juxtaposition with the beds of the series No. 1; and therefore it could not be determined whether they were conformable or not; or whether the former are distinct, indicative of a second period of change in the general features, and therefore of the deposits and molluscan fauna, of the lake, as I imagine may be the case.

A cliff under the village of Babel, on the east side of the lake, presents a good section of this series of deposits forming the extremity of the Steppe.

Fig. 3.—*Section of the Steppe Deposits near Babel, on the east side of Lake Yalpuk.*

b. Porous earthy marl, without fossils. About 70 feet.
a. Brown clay, with bands of fossils. About 25 feet.

The cliff at Babel (fig. 3) is about 130 feet high, and is composed of loose sands, marls, and sandy marls, but changing so slightly, or so gradually, as to show no distinct stratification except by colour.

a is about 25 feet of brown clay or marl; containing numerous fossils, particularly towards the upper part of it, where the fossils lie in beds in great abundance. Some of the fossil shells (*Dreissena*) having both valves, indicate that they lived where they have been deposited, without any violent transport of the sediment having taken place. A delicate and minute *Valvata* and a small *Planorbis* also occur, associated with a very large

Paludina, a *Limnœa*, and a very large *Cardium*, somewhat similar to those found living in the adjacent lake and the Danube.

This portion of the deposits at Babel appears to me to have been tranquilly deposited during a second condition of the lake, when these new and characteristic shells were living in it. Similar fossils and the same conditions of the strata occur in the cliff on the opposite side of the lake at Bardur*.

The whole of the fossils in this series resemble the living species more than those contained in the lower group No. 1, which is seen only in the upper half of this lake; the characteristic striated bivalves of group No. 1 being wanting in this group No. 2, as far as I have observed.

This lower and fossiliferous portion of the above section at Babel is succeeded by about 70 feet of unfossiliferous brown marls or earthy marls (*b*) that very much resemble the superficial or drift series; but I could not clearly define a positive separation between *a* and *b*; although, from some appearances of such division, I think it may exist, and that we have here a section of both the series No. 2 and No. 3. Fossil bones, much worn, of some large animal were found at the base of this cliff; and I have been informed that the remains of fossil Elephants and other large Mammalia have been procured from the upper series of Steppe-deposits in several localities.

I found the same geological and palæontological characters in the deposits of the Steppe at Galatz and near Ibrail, as well as more in the interior of Wallachia. Approaching the Carpathian chain, I found that they became more gravelly, particularly on the line of the Seereth.

The foot of the Carpathian mountains between Foksehan and Rimni is composed of vast gravel-beds, rising several hundred feet above the Wallachian plateau, of which it forms the abrupt boundary.

These gravelly beds seem to have been deposited under great disturbance, and to be of late origin. They have been derived apparently from the rocks of the Carpathians during some great upheaval, accompanied by some great water-action operating powerfully and extensively. This mass of debris, whether of prior or of contemporary origin, must have greatly contributed to the superficial or drift

* The following list has been drawn up by Mr. Woodward on examining Capt. Spratt's specimens:—

Fossil shells from under Babel and Bardur, Lake Yalpuk.

Paludina vivipara?
Valvata piscinalis.
Lithoglyphus naticoides, *Fér.*
Melanopsis Esperi, *Fér.*
Hydrobia Caspica, *Eichw.*?
Bithynia variabilis, *Eichw.*?
Neritina fluviatilis (= Danubialis).
——, sp.
Limnæa auricularia.
Limnæa, sp.; very slender fragment, like young of *L. stagnalis*, var. *fragilis.*
Planorbis marginatus.
——, sp.; slightly keeled.
Cardium.
Cyclas rivicola.
Pisidium.
Dreissena polymorpha.
Unio (fragment).

deposits corresponding to No. 3. I found that even at Fokschan, as at Galatz, the water of the town-wells was often so saline, owing to its containing some mineral salt, as to prevent its being drunk by the inhabitants. But I was informed such wells were not universal, as some penetrated springs of good water.

In no part of the intermediate district were there any evidences of a late Tertiary deposit of *marine* origin. The freshwater marls or the superficial drift cover Wallachia, as also Moldavia, Bessarabia, and the Dobrutcha; the latter with its earthy marls and gravels, and without any contained fossils but those which indicate transport by their fragmentary nature.

Having sent to the Society a few fossils (with those from Moldavia) that came from the borders of the Danube near Rassova, and comprise a peculiar striated bivalve (*Cardium* or *Didacna*) that seems to associate the Rassova deposits as a portion of the freshwater series, similar to the Bolgrod beds, I may here mention that I am indebted for these to my friend M. Lefort, commanding the French gun-boat stationed on the Danube, and who made an interesting trip in his vessel as far as the Iron Gates. I gladly acknowledge this act of courtesy on his part in thus so liberally sharing with me these specimens which he had himself procured so high up the Danube, on my pointing out the interest they possessed in connexion with my geological researches in other localities.

I shall now briefly notice that the Black Sea seems to me, since it has become purely a salt sea as at present, to have been limited to the strait which separates the end of the Moldavian Steppe at Latanof, from the Isaktcha Hills on the Dobrutcha side of the river, as the distance is only about $1\frac{1}{4}$ mile between; and when the sea reached it, the distance was no doubt less; as it would now be, if the delta and river there did not fill much of the intermediate distance, at a level several feet above the Black Sea. It thus then, I think, would present a sufficient contraction to form a barrier against the sea, with the shallow embouchure of such a river as the Danube. The river itself must have been the agent that opened the channel which here divides, by only a little more than its breadth in many parts, the superficial deposits of the Steppe on the Moldavian side from the same deposits which cover the surface of the Isaktcha ridges on the Turkish side; thus admitting it to the Black Sea: the river's marine delta commencing at this point.

These superficial deposits must undoubtedly have at one time been united there, and thus enclosed the upper basin within Isaktcha, as a true Danubian lake. Here the striated bivalves that we found fossil in the freshwater deposits of the Steppe, and now in part apparently living in the present lakes, must have been preserved, only slightly varying in character under some influencing condition as the lake approached the present time.

I think it probable even that others of these bivalves (as the *Adacna*) may still be found living; as I found the large Cardium-

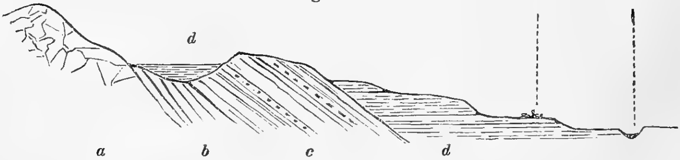
like bivalve, and two or three others, such as the *Monodacna Caspica* and *Adacna plicata?* of Mr. Woodward's list annexed, in the Yalpuk Lake*.

As I was not provided with my dredges when in the Yalpuk Lake, my living specimens were chiefly obtained by diving for them in different depths beyond 5 and 6 feet. As freshwater shells have a great permanency of character through geologic time, these may in all probability be still found in the upper lakes or basins of the Danube, that must have been in connexion with the Black Sea basin when the latter was a purely freshwater lake, and perhaps when at a higher level, as I believe it to have been. The living *Cardium* in the Bolgrod Lake could only have been brought there by the Danube; for this has become a freshwater lake by retaining the back-water of that river when flooded at its annual rising; the River Yalpuk being too insignificant to be the real cause of the freshwater condition of the lake. Prior to the formation of the delta, this inlet in the Steppe, as well as those adjacent, must have contained the Euxine shells; as it was then a mere lagoon open to the Black Sea, just as the Raselm Lagoon now is. Associated with the purely freshwater bivalve found on the shores of the delta, is a very pretty flat bivalve (see specimen sent), which at first I thought must have also been found living in the river, or the lakes adjacent, like its then doubtful associate, the Yalpuk Cockle (*Cardium*). But I at length found it living in the Black Sea, and plentiful also in the equally salt lagoon of Raselm; so that this is as purely a marine shell as the Yalpuk Cockle is purely freshwater.

I shall now briefly notice some sections of the formations bordering the southern side of the Danube near Tultcha and Besh Tepeh; and others on the margin of the Raselm Lagoon, where I obtained some very interesting geological facts and specimens indicating the age of these strata.

Fig. 4.—*Section on the South side of the Danube near Tultcha.*

Fig. 4.



a. Trap? *b.* Highly inclined siliceous rocks.

* Mr. Woodward's list of the recent shells obtained by Capt. Spratt on the freshwater lake of the Steppe adjacent to the Danube:—

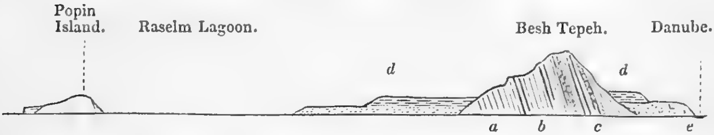
Paludina vivipara.	Cardium, sp.
Melanopsis acicularis.	——, sp.
Lithoglyphus naticoides.	Monodacna Caspica?
Rissoa (Hydrobia), sp.	Adacna plicata.
Neritina fluviatilis, var. Danubialis.	——, sp.
Planorbis corneus.	Dreissena polymorpha, adhering to Cardium.
Limnæa, sp. (aff. *palustris*).	

c. A mass of stratified calcareous shales. The shale encloses nodules of semicrystalline limestone, from which it has the appearance of being a conglomerate. It has perhaps been altered by heat. These beds incline from the trap-rock (*a*) at an angle of 75° towards the N.E. by N., and are about 300 feet in thickness.

d. Brown marls, of the superficial or drift series; between 200 and 300 feet above the Danube.

At Isaktcha, rocks similar to *a*, *b*, and *c* in fig. 4, are overlaid by the superficial marls *d*, and occasionally appear through them. They show considerable disturbance, arising from a protruded volcanic mass which appears to the west of the ruined town of Isaktcha.

Fig. 5.—*Section from the Danube to the Raselm Lagoon.*



In fig. 5 we have a section from the Danube across Besh Tepeh to Popin Island, in the Raselm Lagoon.

a. Stratified schistose rocks, very hard.
b. Dark-veined shales.
c. Calcareous shales and schists; nearly vertical.
d. Brown marly sands of the Steppe; no fossils.
e. A cliff of brown sandy marls over the Danube, with beds of fine gravel, formed of fragments of rocks similar to those of the Besh Tepeh Ridge.

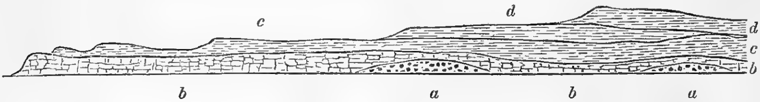
Popin Island is apparently an outlying mass of the calcareous shales and schists *a*, *b*, *c*; and is partially flanked with the unfossiliferous brown sandy marls of the superficial or drift series.

The calcareous shales here are more calcareous than in the Besh Tepeh and Tultcha range, and contain abundant fossils, possibly of the Triassic (?) age.

It has yet to be determined whether the Isaktcha Rocks, which are all similar, are not of an older period; and these rocks seem to extend in one continued chain to Matchin. South of Matchin is a long valley opening into the Raselm Lake at Baba Dagh, or rather at Yeni Keni, where there was an ancient Greek colony, and where still exist the picturesque ruins of a Genoese castle. The ancient name, according to local tradition, was Eraklea. The town no doubt stood on the Black Sea at the Greek, if not at the latter, period. On the south side of this long valley, which extends nearly to Matchin, rises another range of hills, parallel to the Tultcha range, but of less height. Its extremity juts into the Raselm Lagoon to the south and east of Baba Dagh and Yeni Keni (or Eraklea); and the northern coast of this point or promontory presents the following

section, which shows rocks and characters entirely differing from those of the Tultcha range. We have here an upper member of the same group, if of the same age: or it belongs to a newer formation.

Fig. 6.—*Section of the Promontory eastward of Yeni Keni (or Yeni Sel), Lake Raselm.*



a. A red conglomerate. The fragments which it contains are of schists and shales, but there are none of limestone; neither are they rounded, as if water-worn.

b. Compact limestone, grey and reddish, much veined, and semi-crystalline; 20 feet thick.

c. Compact calcareous strata, associated with schists and shales, thinly stratified, and fully 50 or 60 feet thick; but, being overlaid by the superficial marls (*d*), they are not fully seen. The beds *c* correspond with the thinly stratified grey and yellow calcareous shales forming the next cape or promontory to the south, called Dolashina, where they contain *Inocerami*. Here also they lie nearly horizontal, and are again capped by the superficial drift, which extends thence to Cape Media, where the dark vertical shales appear, and then the cream-coloured Inoceramus-limestones; followed by the Chalk at Kanara, described in my former papers*.

Thus supplying some links in the line of research, it is hoped that these notes and remarks will, by the aid of the fossils already presented to the Society, throw some light on the geology of the Dobrutcha.

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3. *On the* Rhizopodal Fauna *of the* Mediterranean, *compared with that of the* Italian *and some other* Tertiary Deposits.

By T. Rupert Jones, Esq., F.G.S. and W. K. Parker, Esq., Mem.M.S.

Introduction.—The Mediterranean has been the source whence a large number of the known species of *Foraminifera* have been derived. Beccarius (1731), Plancus (Bianchi, 1739), Gualtieri (1742), Ginanni (1755), Soldani (1780 & 1789), and Fichtel and Moll derived most of the material for their notices of these microscopic shells from the Mediterranean. D'Orbigny also and later naturalists have drawn largely from this rich source.

Of late years, we have been favoured with the results of many dredgings taken in different parts of the Mediterranean by Prof.

* Quart. Journ. Geol. Soc. vol. xiv. p. 207, &c.

E. Forbes and Capt. E. Spratt, also with shell-sands from Leghorn and Venice by Mr. W. J. Hamilton, and with other shell-sands from both sides of Italy by Prof. Meneghini and the Marchese Carlo Strozzi (through the zealous kindness of Dr. H. Falconer), with sponge-sands from Crete and elsewhere (communicated by friends), and we have obtained other like material from various sources. We have thus been able to work out a very large series of the Mediterranean *Foraminifera*.

The authors already mentioned, as well as Defrance and others, have also described a large number of fossil *Foraminifera*, obtained from the Tertiary deposits of Tuscany, Piedmont, and other countries bordering the Mediterranean. These bear a close relation to the recent forms of the same area; and towards the elucidation of their affinities, we can now bring forward the results of a careful examination of an extensive series of the fossil *Foraminifera* of the Mediterranean region, either supplied to us by some of the friendly hands above referred to, or obtained from the Museum of this Society and other sources, especially (in the case of the Malaga clays) through Professor Ansted. We have also been favoured by Dr. Wilhelm Haidinger with a large quantity of the Nussdorf Marl (Amphistegina-bed) from the Vienna Basin; and from Baljik (on the Black Sea) we have received, through the hands of Capt. Spratt, a most interesting sample of a Tertiary deposit which affords marked Rhizopodous alliances with the so-called Miocene fauna of the Vienna basin and the Pliocene fauna of Mediterranean Tertiaries.

We propose to arrange in a Synoptical Table the species and varieties of *Foraminifera* which we have found in the gatherings, dredgings, and soundings brought from several (26) localities of which we have definite information; and in many cases the shells obtained at different depths, or in distinct sea-zones, in one locality will be discriminated, on account of the importance arising from the variability of a given species under different conditions of depth and sea-bottom. We follow the same plan with the fossil forms; in some instances the different beds of the deposits being treated separately. In every case where we offer tabulated results we feel satisfied of having had at our command a sufficient quantity of material to afford trustworthy evidence.

We prefer to tabulate the fossil *Foraminifera* of the Vienna basin from D'Orbigny's beautiful Monograph, and from the elaborate Memoirs of Czjzek and Reuss, not yet having had time to do justice to the valuable Viennese material supplied us by Dr. Haidinger.

With respect to the nomenclature adopted in our Table, we have, in the first place, been careful to eliminate all unnecessary binomial terms, such as duplicate names, or names given to but slightly varied individuals; and at the same time we have enumerated many well-marked varieties in each species, because of their value as indications of peculiar conditions of habitat; and because, many of them presenting at first sight striking differences of form, size, and ornamentation, and being easily mistaken for types of distinct specific groups, they have acquired an importance in the eyes of zoologist

and geologist which makes it convenient to give them a sort of subspecific value and a binomial term.

It has been doubted by some whether in this, the most variable, because simplest, family of the animal kingdom, every variety should not be distinguished by its own binomial appellation,—a plan that has been followed almost to the full by many naturalists. In this, however, we cannot agree, for the unlimited multiplication of quasi-specific names, linked together by pseudo-generic titles, can only weary the catalogue-maker, and throw obstacles in the way of the systematist; for it keeps up a false notion of the value of external characters which are rarely essential, whilst no clue is thereby obtained to the morphological law of each real specific type. Evidences of such law, however, are not wanting when we carefully examine varietal forms as they diverge, and, as it were, radiate, from a given central type.

Though Linnæus was somewhat parsimonious in giving names to the microscopic shells which he knew, and though Fichtel and Moll partially indicated their great variability, and were cautious in naming them, yet it was not until Dujardin demonstrated the nature of the Rhizopodous sarcode and its simple, non-differentiated character, and until Williamson and Carpenter, taking up the study of certain species, showed what extreme forms might be connected together by innumerable gentle intermediate gradations, that anything like a really scientific appreciation of these Microzoa may be said to have existed. Our own experience of the wide limits within which any specific group of the *Foraminifera* multiply their varietal forms, related by some peculiar conditions of growth and ornamentation, has led us to concur fully with those who regard nearly every species of *Foraminifera* as capable of adapting itself, with endless modifications of form and structure, to very different habitats in brackish and in salt water,—in the several zones of shallow, deep, and abyssal seas,—and under every climate, from the poles to the Equator. Our principles of nomenclature, and the application of them, may be seen in our papers on *Foraminifera* in the 'Annals and Mag. Nat. Hist.'

Remarks on the Materials of the Tabular Synopsis.—In arranging our synoptical tables of the Mediterranean *Rhizopoda*, recent and fossil, and in comparing their numerous specific and varietal forms one with another, we have not confined ourselves to our collections from this region, but have necessarily made comparisons of forms from almost every part of the globe, from the Arctic and the Tropic Seas, from the temperate zones of both hemispheres, and from shallow, as well as deep sea-beds. Geologically, also, we have reviewed the *Foraminifera* in their manifold aspects as presented by the ancient faunas of the Tertiary, Cretaceous, Oolitic, Liassic, Triassic, Permian, and Carboniferous times; finding, to our astonishment, that scarcely any of the species of the *Foraminifera* met with in the Secondary Rocks have become extinct; all, indeed, that we have as yet seen have their counterparts in the recent Mediterranean deposits. This is still more clearly found to be the case with regard to the Chalk of Maestricht and the Tertiaries.

Taking the recent Mediterranean *Foraminifera* systematically, we commence with the littoral fauna, comprising those met with in the seaweed-zone, and those washed up by the waves and found between the tidal lines, or occasionally in sand-banks blown up by the wind. Amongst those obtained under these circumstances are the numerous specimens found in sponges, when the latter have been thrown on the shore and trampled or washed about in the sand. Samples of such littoral shell-sand we have from the Golfo di Spezzia*, Leghorn†, and Crete ‡, from shores having a western aspect; from the sand-bank of Lido § (Venice), and from Rimini ||, in the Adriatic. The equivalent deposits of the Levant, including those off the Nile, we retain for future description.

Our selected examples from the next stages of sea-depths are from 40 fathoms at Suda Bay, north side of Crete ¶, from 90 fathoms off Syra in the Archipelago**, from 170 fathoms off Serpho in the Archipelago††, from 250 fathoms to the north-west of Crete ‡‡, from 360 fathoms near Crete §§, from 500 fathoms near Ipsara in the Archipelago ||||, from 1100 fathoms between Crete and Santorin ¶¶, from 1620 and 1650 fathoms between Malta and Crete ***, and from 1700 fathoms between Malta and the Archipelago †††.

The fossil *Foraminifera* of the Mediterranean area will be illustrated in our columns by lists of species from the Tejares clay of Malaga, the shelly beds of Turin, several deposits from Sienna, the shell-beds of Palermo, the fossiliferous Tertiaries of Malta, those of the Vienna basin, and lastly, from a shell-bed at Baljik, near Varna, on the Black Sea. The last three of these deposits are regarded as being of Miocene age,—the others, with one or two exceptions, as Pliocene.

The richest of these are the Siennese Subapennine beds, samples of which have been freely communicated to us by Prof. Meneghini and the Marchese Carlo Strozzi (through the hands of our friend Dr. Falconer). The following is the list of these beds from which we have specimens (Nos. 1–8 are from Prof. Meneghini; Nos. 9–12 from March. C. Strozzi).—1. Blue clay, from Cerajolo and Santo Donnino (see Soldani's 'Testaceographia,' vol. ii. p. 26). 2. Blue clay, from S. Lazzaro, near Sienna (see Soldani, 'Testaceographia,' vol. ii. p. 42). 3 and 4. Blue clay, from Coroncina, near Sienna (see Soldani, 'Testaceographia,' vol. ii. p. 79). 5. Blue clay, from S. Quirico, not far from Sienna. 6. Clay, from Pescaja, near Sienna (rich in *Entomostraca*, but poor in *Foraminifera*). 7. Sand, from Pienza, in the Siennese. 8. Clay, from Monte Arioso, near Sienna. 9. "Sabbie Gialle di Montopoli," Tuscany (upper Pliocene). 10. Castell' Arquato nel Piacentino (Pliocene). 11. "Delle Crete Senesi" (Lower

* From Prof. Meneghini.
† From Mr. W. J. Hamilton and the Marchese Carlo Strozzi.
‡ From Mr. Dines.
§ From Mr. W. J. Hamilton.
|| From Prof. Meneghini and the Marchese C. Strozzi.
¶ From Mr. Huxley.
** From Capt. Spratt.
†† From Capt. Spratt.
‡‡ From Capt. Spratt.
§§ From Mr. Hilton.
|||| From Capt. Spratt.
¶¶ From Capt. Spratt.
*** From Capt. Spratt.
††† From Capt. Spratt.

Pliocene). 12. St. Frediano, Colline Pisane (Miocene); this last and No. 7 resemble the Amphistegina-bed of the Vienna Basin.

Nos. 1–4 will be grouped together in one column, as they contain but one series of forms, with a great uniformity of mineral matter.

Excepting the Amphistegina-beds, the Italian Tertiaries under notice yield *Foraminifera* similar to those of the Mediterranean, both of shallow and deep habitats.

The next columnized group will be that from Malaga. In the Quart. Journ. Geol. Soc. vol. xv. p. 597 and p. 600, Prof. Ansted has described the geological relations of the Tejares clay of the neighbourhood of Malaga, and has briefly alluded to its very rich Rhizopodal fauna. This is the richest, next to that of the Siennese tertiaries, that we know of, and well agrees with that of the present Mediterranean, especially the Adriatic.

Fossils in the collection of the Society, from the neighbourhood of Turin, have afforded the shelly sands from which the next column of species has been arranged. In many respects these are equivalent to some of those from the Siennese district; especially the more shallow-water forms.

Palermo gives us the next column; these materials being also from the Society's collection. This fauna is more like that of the recent shallow-water Mediterranean deposits than most of the Siennese or the Malaga clays.

Our Maltese *Foraminifera* belong to another fauna, characterized by the abundance of *Heterosteginæ* (the reddish fragile limestone being almost wholly composed of this shell). The recent analogue of this fauna has to be sought for in the Eastern seas (Philippines).

The Vienna Basin has afforded, as palæontologists well know, a large series of *Foraminifera* to the patient researches of D'Orbigny, Czjeck, and Reuss. Like the Amphistegina-beds of Italy and the Heterostegina-rock of Malta, these Viennese Tertiaries are of older date than the Pliocene beds of the Subapennine series, and are regarded as of Miocene age, or Oligocene of the German geologists. The Viennese species have been so carefully figured and described by the above-named palæontologists that we gladly use their materials in our columns of the Mediterranean species and of the fossil faunæ that preceded them in that area and the conterminous regions.

A very important relic of an old fauna closely allied to the Miocene forms of some of the Vienna deposits, and not without some relationship to the Eocene beds of Grignon, is indicated by a whitish shelly marl from Baljik, containing also remains of aquatic mammals. This is referred to in the Quart. Journ. Geol. Soc. vol. xiii. p. 77, by Capt. Spratt, who has also kindly supplied us with a quantity of this valuable material for examination. This affords a curious and instructive fauna, allied to that of the Mediterranean, but having remarkable peculiarities. In mineral character it much resembles the deep-sea deposits of the Mediterranean, having a large proportion of greyish-white aluminous matter, and a considerable quantity of fragments of Molluscan shells, with but a few that are perfect, and those small. It does not, however, contain the delicate

small Pteropodous shells so common in deep soundings in the Mediterranean.

In this instance we have taken in hand the Mediterranean *Foraminifera* and their older relatives found in the neighbouring Tertiary deposits. We propose, if circumstances permit, to present at another time comparative views of other faunas, such as those of the Atlantic with the fossil *Foraminifera* of Bordeaux and the Faluns —and those of Australia compared with the well-known Grignon forms, &c.

Notes on the several Columns in the Table.—Columns Nos. 1 to 11, illustrating the recent Rhizopodal fauna of the Mediterranean, will require a detailed history of their interesting contents too long for the present occasion. The value of these columns, as terms of comparison, will be shown in treating of the fossil forms tabulated in Columns Nos. 12 to 28.

Column No. 12. Blue Clays from Cerajolo and S. Donnino, from S. Lazaro, and from Coroncina.

These Siennese clays (for which we are indebted to Professor Meneghini) are exceedingly rich in the Nodosarian and Cristellarian species. They also abound with the Bulimine, Textularian, Rotalian, and Nonionine groups; but are poor in *Lagenæ*, *Polymorphinæ*, and *Polystomellæ*. The *Miliolæ* are moderately represented, but not proportionately abundant.

This deposit is amongst the richest of those containing the "Stichostegian" *Foraminifera* that we know of; the only comparable instances being the Malaga and Vienna clays. Several of the Cretaceous and Jurassic deposits (chiefly clays) are also extremely rich in this group. In the recent state we find the *Stichostegia* generally rare in littoral deposits. At Rimini they are exceptionally abundant; the shore-sand there being almost as markedly characterized with them (though of smaller size) as the Subapennine clays are. In column No. 4 we have, from ninety fathoms, a fine series of Stichostegues, nearly equal to those from Rimini; but the minor varieties have more delicate shape, with thicker shell-walls: conditions obtaining in every group of *Foraminifera* in deep water. In abyssal depths of the Mediterranean, as well as of the open ocean, the Nodosarian group becomes rare, and the specimens are very small.

As to the Bulimine group, column No. 12 agrees well with No. 4, and is not very dissimilar from Nos. 5, 6, & 7; but in the two latter (250 and 360 fathoms) most of these forms are of much diminished size. The same may be said of the Textularians. The favourite range of *Bulimina* and *Textularia* appears to be (from what we have seen in the Mediterranean and elsewhere) from 20 to 200 fathoms.

The *Cassidulinæ* are represented by varieties that are usually found, in sands and clays, at from about 50 to 150 fathoms.

Orbulina and *Globigerina* (with their two allies the so-called *Nonionina sphæroides* and the *Sphæroidina bulloides*) are faithful indicators of abyssal depths, though occasionally found in shallow

water. In column No. 12 these forms are well represented by full-sized individuals, though not in a large proportional number.

Of the leading Rotalian forms, we have here some of the varieties of *Rotalia* (*Planorbulina*) *farcta* that are usual in moderately deep water; so also of *R. repanda*; the varieties of *R. Beccarii* are those of deep water; the varieties of *R. Turbo*, which usually affects shallow waters and sandy bottoms, are feebly represented here.

The *Nonioninæ*, and their more highly developed relatives the *Polystomellæ*, seem, by the varieties here present, to indicate a moderate depth.

Of the opake-shelled *Foraminifera* we have here a few good varieties of *Miliola*, inhabiting deepish water; the truly littoral forms being almost wanting. Of the rest of the opake group, there are some large helicine specimens of *Lituola nautiloidea*, and a few smallish *Cornuspiræ*, none of which inhabit shallow water.

From the evidence thus gathered by a comparison of the contents of column No. 12 with the Foraminifers of the existing seas and oceans, we may conclude that these particular Siennese clays were deposited at a depth of not less than about 40 fathoms, and not more than about 100 fathoms. We must remember here that an area of a clay-bed or any other sea-deposit may have a considerable extension under a gently varying depth of water, within certain limits; and that samples of the same clay-bed taken from within a few miles, or even yards, of each other, may yield somewhat dissimilar portions of one great well-characterized fauna. Thus we may take our specimens from the spot where the littoral overlaps the deep zone, or where the latter is sliding into the abyssal. The wide limit of from 40 to 100 fathoms, indicated for the Siennese clays, illustrated by column No. 12, may be thus accounted for.

No. 13. Blue Clay from S. Quirico (Professor Meneghini).

From the smallness of the specimens, and the proportional abundance of *Globigerina*, this was very probably formed in a depth of from 150 to 250 fathoms.

No. 14. Blue Clay from Pescaja (Meneghini).

This yields numerous small specimens of *Rotalia Beccarii* intermixed with innumerable *Entomostraca* (*Cythere Muelleri*, var.). From the small size of the *Rotalia* and the presence of this *Cythere*, we may confidently interpret this clay as a deposit of shallow and probably brackish water. Both *R. Beccarii* and *C. Muelleri* are found to range upwards into estuaries and salt-marshes.

No. 15. Sand from Pienza (Meneghini).

This is an Amphistegina-bed. It has a few shallow-water forms besides the *Amphistegina*, especially *Rotalia Beccarii* and *Polystomella crispa*, which are large and abundant. We best know *Amphistegina*, in the Canaries, West Indies, and Eastern Seas, in shell-beds at from 20 to 40 fathoms. In the white mud from the Australian reefs (10 to 20 fathoms), dredged by Mr. Jukes, and rich in Foraminifers, *Amphistegina* is large and common. We have not met with a recent *Amphistegina* in the Mediterranean.

We may suppose the Amphistegina-bed of Pienza to have been formed at no great depth; perhaps at not more than 10 fathoms, if we are swayed by the presence of the *R. Beccarii* and *P. crispa*, as indeed we ought to be.

Amphisteginæ form a large proportion of the material of some other fossil deposits in the neighbourhood of the Mediterranean (as shown in columns Nos. 17, 18, 20, 21, & 23). It abounds in the white Nussdorf marl of the Vienna Basin; and is not absent from the Malaga clay. It may yet be found in some part of the Mediterranean; but, as it seems to have disappeared from this area, geologists may be right in setting a value on its abundance in some of the Tertiary beds, and in regarding it as indicative of the Miocene period. It abounds in the Miocene Tertiaries of San Domingo.

No. 16. Clay from Monti Arioso (Meneghini).

The fauna here is made up of *Rotalia Beccarii* with a few other shallow-water forms.

No. 17. "Sabbie gialle," Montopoli (Strozzi).

This yellow sand much resembles in its fauna No. 15; but the *Amphistegina* is here accompanied with a larger suite of *Rotaliæ*, *Polystomellæ*, *Textulariæ*, &c., with some *Miliolæ*. The varieties here present indicate rather deeper water than that peculiar to the fauna of No. 15.

No. 18. Castel' Arquato (Strozzi).

This also has *Amphistegina*. It contains also *Operculina complanata*, which is, however, feebly developed in the Mediterranean; but this is very rare at Castel' Arquato, and may have been a "derived" fossil, being very much worn. This deposit was formed in shallow water, and has much agreement with the fauna of column No. 1, in its many well-developed littoral forms.

No. 19. "Delle Crete Senesi" (Strozzi).

This, like No. 14, is extremely rich in *Rotalia Beccarii*. It has also many good-sized specimens of *Polystomella crispa*, a few *Miliolæ*, and a unique specimen of *Dactylopora*, which looks worn, like a "derived" fossil. *Dactylopora* is a characteristic Eocene Foraminifer; it is not found in the Mediterranean; but the subtropical seas yield some small specimens, exhibiting, as it were, an arrest of growth*. It occurs also in the Miocene clays of San Domingo.

No. 20. San Frediano (Strozzi).

Another Amphistegina-bed with a few littoral forms besides its abundant *Amphisteginæ*. *Polystomella* is again large and common, as in most of the Amphistegina-deposits.

No. 21. Tejares Clay, Malaga (Ansted).

What we have said respecting column No. 12 holds good for the Rhizopodal fauna afforded by this Malaga clay. At from 170 to 500 fathoms in the Mediterranean very many of the same group of forms occur, but the individuals are smaller. At from 1100 to 1700 fathoms there are fewer, and many of them very small; but *Orbulina* and

* See Annals of Nat. Hist. 3rd ser. vol. v. p. 473.

Globigerina are largest here and most common. In the middle depth also these two genera present the best developed forms both in number and size.

One of the Rhizopods in the Tejares Clay particularly deserves notice, namely the *Frondicularia*, which we here find very large. Soldani figures similar large specimens from the Siennese deposits; but we have met with small ones only. In the recent sand from Rimini we find large, worn, and probably "derived" *Frondiculariæ*, having their chambers occupied with ferruginous clay, as is the case with the large fossil *Cristellaria* of Sienna. D'Orbigny had large *Frondiculariæ* from the Viennese Tertiaries; and we find some in the Tertiary beds of San Domingo*.

No. 22. Turin (Geol. Soc.).

Characterized by very large *Nodosariæ* and *Cristellariæ*, the Turin deposits which we have examined have the general features of the Pliocene Tertiary. A considerable number of forms, just as may be found on the western shores of Italy at this day, combined with gigantic *Cristellariæ* and the largest of known *Nodosariæ*, compose the fauna in this column No. 22.

No. 23. Palermo (Geol. Soc.).

Our specimens from the tertiary deposits of Palermo yield a very rich fauna of rather shallow-water forms, commingled with some from deeper zones. *Amphistegina* is present here also, and is common, though not preponderating. The Textularian, Rotalian, and Miliolite groups are in force; there are a few traces, however, of the *Nodosariæ* and *Cristellariæ*. This fauna has much resemblance to the large assemblage of forms which Mr. S. V. Wood, F.G.S., has collected from the Crag at Sutton in Suffolk. With the latter, however, the existing sea-bed, at 21 fathoms†, off the north-west of Sicily, has such close relations, as to the varieties and conditions of the *Foraminifera*, that we may regard them as almost identical.

No. 24. Malta (Geol. Soc.).

The Heterostegina-bed at Malta is not without smaller Foraminifers (some of which we can identify,—as the *Globigerina bulloides*, *Truncatulina lobatula*, &c.), but the matrix is too stubborn to yield all its treasures. The *Heterostegina*‡ (which is found also in the Vienna Basin) appears to be extinct in the Mediterranean.

Nos. 25, 26, 27. Vienna Basin. (D'Orbigny, Czjeck, and Reuss.)

The remarkably rich fauna obtained from different deposits in the

* We have lately met with a long narrow *Frondicularia* (like *F. striatula*, Reuss) in Commander Dayman's dredgings, made in July 1859, off Lisbon, at 700 fathoms.—May 26, 1860.

† Shown by the dredgings made by the Commander of H.M.S. 'Queen,' August 1851.

‡ Spratt, Forbes, and Wright, in their notices of the Maltese strata and fossils (Proc. Geol. Soc. iv. pp. 226 & 230; and Annals Nat. Hist. 2 ser. xv. p. 101, &c.), have misnamed this Foraminifer, referring it erroneously to *Lenticulites* (*Operculina*) *complanatus*, Basterot. *Operculina complanata* occurs in a hard white limestone at Malta; and for a very fine specimen we are indebted to Lord Ducie, F.G.S.

Vienna Basin have been elaborately studied by D'Orbigny, Czjeck, and Reuss. We find in their works figures and descriptions of nearly every form mentioned in our columns Nos. 12–24, and a large majority also of the species and varieties that are found living in the Mediterranean.

One of these deposits (marl at Nussdorf) is abundantly rich with *Amphisteginæ*. Here also *Alveolina* occurs, as well as at Baden. These forms are extinct as to the present Mediterranean. *Orbiculina*, as a small variety, has been found fossil at Buitur in Transylvania*; this also we have not met with living in the Mediterranean, though others have mentioned it.

The forms figured by Czjeck may be for the most part regarded as *intermedia* between the bolder forms figured in D'Orbigny's great work; at the same time they comprise some very important varieties, and a few are new varietal types.

Reuss also has figured, besides a few new forms, numerous *intermedia*, most of them being delicate varieties of the subspecies so well shown in the large work by D'Orbigny, and of considerable value to the zoologist.

No. 28. Baljik. (Capt. Spratt.)

A whitish marl characterized by a few peculiar forms, some of them extremely rich in individuals. The *Polystomellæ* and *Nonioninæ* afford multitudes of minute specimens, and also the beautiful and rare spinose form termed *P. Regina* by D'Orbigny; it is the *P. unguiculata*, Gmel. sp. D'Orbigny had it from the Vienna Basin; Gmelin's specimen came from the Red Sea. *Vertebralina inæqualis*, Gmel., obtained by Spengler, and also by ourselves, from the sand of the Red Sea, and which is common in the Calcaire Grossier of Grignon, occurs in the Baljik marl, common and large. A few *Miliolæ* and *Lagenæ*, and an occasional *Rotalia Beccarii* and *Nubecularia* complete the list of *Foraminifera* obtained by the careful examination of some pounds of this marl.

We have here evidently an old sea-bed of the seaweed-zone (probably at a depth of from 10 to 20 fathoms), having relations, it would seem, rather with the fauna of the Red Sea than with that of the Mediterranean.

Notes on the Species and Varieties.—Many of the species and varieties mentioned in the foregoing Table have been named (as species) by D'Orbigny in the 'Annales des Sc. Nat.,' after figures published in Soldani's 'Testaceographia' and 'Saggio Orittografico†;' and, as we have had the opportunity‡ of referring at our leisure to Soldani's great work, we have verified and adopted these names, often to the exclusion of synonyms that have been needlessly multiplied in works subsequent to those of the authors mentioned.

* D'Orbigny, For. Foss. Vien. p. 142.

† This appears also in the form of an Appendix to the 'Testaceographia,' vol. ii.

‡ Through the kindness and liberality of Dr. Falconer, F.G.S., who for our sake purchased in Italy a perfect copy of this expensive work, the loan of which we at present enjoy.

Some other varieties and species are but little known, and call for a few remarks as to their structure and alliances. Others are determined here for the first time, and require a few words of notice.

1–43. The varieties here enumerated comprise nearly all the best marked and most distinct forms known of the genus *Nodosarina*, including *Nodosaria* and *Cristellaria* and all their varieties. The Flabelline subgroup, however, is not well represented, though some of the *Cristellariæ* here put on to some extent the essential features of *Flabellina*. We have elsewhere stated* our views of the close relationship of *Dentalina*, *Lingulina*, *Frondicularia*, *Dimorphina*, *Rimulina*, *Vaginulina*, *Planularia*, and *Marginulina* to *Nodosaria* on one hand and *Cristellaria* on the other.

3. *Nodosaria ovicula*, D'Orb. Ann. Sc. Nat. vii. p. 252, No. 6; Soldani, Testaceograph. ii. pl. 10. figs. H–M; *N. longiscata*, D'Orb. For. Foss. Vien. p. 32, pl. 1. figs. 10–12.

4. *N. Pyrula*, D'Orb. Ann. Sc. Nat. vii. p. 253, No. 13; Soldani, Testaceog. ii. pl. 10. fig. B–C; *N. stipitata*, Reuss, Denkschr. Ak. Wien, i. pl. 46. fig. 4.

5. *N. longicauda*, D'Orb. Ann. Sc. Nat. p. 254, No. 28; Soldani, Testaceog. i. pt. 2, pl. 95. fig. B–M; *N. striaticollis*, D'Orb. Hist. Nat. Canar. pl. 1. fig. 2–4.

6. *N. hirsuta*, D'Orb. Ann. Sc. Nat. vii. p. 252, No. 7; Soldani, Testaceog. ii. pl. 2. fig. P; *N. hispida*, D'Orb. For. Foss. Vien. pl. 1. f. 24, 25.

21. *Vaginulina striata*, D'Orb. Ann. Sc. Nat. vii. p. 257, No. 3; Soldani, Saggio Orittog. pl. 6. f. N.

24. *V. marginata*, D'Orb. Ann. Sc. Nat. vii. p. 285, No. 7; Soldani, Testaceog. i. pt. 2, pl. 103. f. M.

28. *Marginulina Falx*. New variety. [Type, *Nodosarina Raphanus*, Linn.] An elegant dimorphous, striated, little *Nodosarina*, with the first six or seven cells arranged in the form of a partially uncoiled trihedral (or *Cristellaria Saracenaria* of Defrance), and with the last two, three, or four chambers rectilinear and not distinguishable from those of *Nodosaria longicauda*, with which this variety is always associated in nature. *N. longicauda* may be regarded as the normal form to which this variety belongs, and is the more prevalent of the two. Soldani has given two or three figures (Testaceog. i. pt. 2, pl. 95. fig. L; pl. 96. fig. P; and pl. 102. fig. 6), which, though wanting in definiteness, may have reference to this variety.

30. *Marginulina hirsuta*, D'Orb. For. Foss. Vien. p. 69, pl. 3. f. 17, 18. This is not the *Marginulina hirsuta* of the Ann. Sc. Nat. vii. p. 259, No. 5, which is *Bigenerina Nodosaria*, as shown by Soldani's figures referred to by D'Orbigny.

* In the 'Annals of Nat. Hist.' 3 ser. vol. iii. p. 477.

n, Tuscany, Northern Sicily, Malta, the Vienna Basin,

. Rather common. R. Rare. VR. Very rare.

19	20	21	22	23	24	25	26	27	28	
...	...	...	...	...	...	...	...	...	...	102.
...	...	*l* C	...	*l* R	...	*	...	...	...	103.
...	...	*l* C	...	*m* C	...	*	*	*	...	104.
...	...	*l* C	*m* C	*m* R	...	*	...	...	...	105.
...	...	...	...	...	*s* RC	*	...	*	...	106.
		m C	*m* C	...	...	...	*	*	...	107.

TABLE OF RECENT AND FOSSIL FORAMINIFERA FROM THE MEDITERRANEAN AND EUXINE AREAS; INCLUDING THE TERTIARY DEPOSITS OF MALAGA, TURIN, TUSCANY, NORTHERN SICILY, MALTA, THE VIENNA BASIN, AND BALJIK IN BULGARIA.

vl. Very large. *l.* Large. *m.* Middle-sized. *s.* Small. *vs.* Very small. VC. Very common. C. Common. RC. Rather common. R. Rare. VR. Very rare.

Genera, Subgenera, Species, and Varieties.	1 Golfo di Spezzia, Leghorn, and Crete.	2 Lido and Rimini.	3 40 fathoms, Suda Bay, Crete.	4 90 fathoms, Syra.	5 170 fathoms, Serpho.	6 250 fathoms, N.W. of Crete.	7 360 fathoms, Crete.	8 500 fathoms, Ipsara.	9 1100 fathoms, between Crete and Santorin.	10 1620 fathoms and 1650 fathoms, between Malta and Crete.	11 1700 fathoms, between Malta and the Archipelago.	12 Blue Clays from Cerajolo and S. Donnino, from S. Lazaro, and from Coroncina.	13 Blue Clay from S. Quirico.	14 Blue Clay from Pescajo.	15 Sand from Pienza.	16 Clay from Monte Arioso.	17 Sabbie Gialle, Montipoli.	18 Castel' Arquato.	19 Dello Crete Senesi.	20 San Frediano.	21 Tejares Clay, Malaga.	22 Turin.	23 Palermo.	24 Malta.	25 Vienna Basin (D'Orbigny).	26 —— (Czjeck).	27 —— (Reuss).	28 Baljik.	
	recent.	recent.	recent.	recent.	recent.	recent.	recent.	recent.	recent.	recent.	recent.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	fossil.	
1. Nodosaria Glans, D'O.	...	l R	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	m C	...	...	...	...	...	...	*	...	*	...	1.
2. —— Radicula, Linn.	...	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	s C	...	...	...	*	...	*	...	2.
3. —— ovicula, D'O.	...	m C	...	...	...	...	...	...	...	...	...	s C	s C	...	...	...	...	...	...	...	l C	...	...	...	*	...	*	...	3.
4. —— Pyrula, D'O.	...	...	m R	...	...	m RC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*	...	4.
5. —— longicauda, D'O.	s RC	m C	...	m C	...	m C	m C	s R	...	...	...	m C	...	...	...	...	...	...	...	...	s C	m C	...	...	*	...	*	...	5.
6. —— hirsuta, D'O.	...	m C	...	...	...	...	s R	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	6.
7. —— Raphanus, Linn.	m R	l VC	s R	s C	s C	m RC	...	...	s RC	...	...	l C	vs C	...	...	...	...	...	...	...	l C	...	...	...	*	...	...	...	7.
8. —— Raphanistrum, Linn.	...	s RC	...	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	l C	vl C	...	...	*	...	...	...	8.
9. Dentalina acicula, Lam.	...	...	m C	l C	l C	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	l C	...	m R	...	*	...	*	...	9.
10. —— acuticosta, Reuss	...	m R	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	10.
11. —— Adolphina, D'O.	...	...	...	...	...	...	...	...	...	...	...	s C	...	...	...	...	...	...	...	...	s C	...	...	...	*	...	*	...	11.
12. —— elegantissima, D'O.	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	12.
13. —— elegans, D'O.	...	...	...	l C	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	13.
14. —— guttifera, D'O.	...	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	14.
15. —— brevis, D'O.	...	...	...	...	...	...	...	...	...	...	...	l R	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	15.
16. —— communis, D'O.	m R	m C	m C	m C	l C	m C	m RC	s C	s R	...	...	m C	s C	...	...	...	...	...	...	...	m C	...	...	...	*	*	...	...	16.
17. Lingulina carinata, D'O.	...	m C	...	l C	...	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	l R	...	...	*	...	*	...	17.
18. Frondicularia complanata, Defr.	...	...	...	...	...	...	...	...	...	...	...	s RC	vs C	...	...	...	...	...	...	...	l C	...	...	...	*	...	*	...	18.
19. Dimorphina tuberosa, D'O.	...	...	...	m C	...	...	s R	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	19.
20. Rimulina glabra, D'O.	...	...	...	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	...	20.
21. Vaginulina striata, D'O.	...	m R	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	21.
22. —— Badenensis, D'O.	...	...	...	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	22.
23. —— Legumen, Linn.	s RC	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	23.
24. —— marginata, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	24.
25. —— tricarinata, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	25.
26. Planularia Cymba, D'O.	...	m VC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	26.
27. —— Auris, Defr.	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	27.
28. Marginulina Raphanus, Linn.	...	m VC	m C	s RC	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	l C	...	...	...	*	...	...	...	28.
29. —— Falx, P. & J.	...	...	...	m C	...	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	29.
30. —— hirsuta, D'O.	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m RC	...	...	...	*	*	...	...	30.
31. —— Lituus, D'O.	...	m RC	...	m C	...	s C	s C	...	...	...	...	s C	s C	...	...	...	...	...	...	...	m C	...	...	...	*	*	*	...	31.
32. Cristellaria Cassis, F. & M.	...	m C	...	m C	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	l C	vl C	...	...	*	...	...	...	32.
33. —— Vortex, F. & M.	...	...	...	m C	...	m C	m C	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	*	...	33.
34. —— costata, F. & M.	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	*	*	...	...	34.
35. —— Calcar, Linn.	...	m C	...	m C	...	...	s RC	...	...	...	...	m C	...	...	...	...	m R	...	...	...	m C	...	...	...	*	...	...	...	35.
36. —— Crepidula, F. & M.	s RC	...	s R	m C	...	...	...	...	...	...	...	s C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	36.
37. —— lanceolata, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	37.
38. —— clypeiformis, D'O.	...	m RC	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	38.
39. —— Italica, Defr.	...	m RC	...	l C	...	...	...	...	...	...	...	vl C	...	...	...	...	...	...	...	...	m R	...	...	...	*	...	...	...	39.
40. —— reniformis, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	s C	...	...	...	*	...	...	...	40.
41. —— cultrata, Montf.	...	m C	m R	m C	...	...	...	...	...	...	...	l C	...	...	m R	...	...	...	...	...	l C	...	...	...	*	...	*	...	41.
42. —— rotulata, Lam.	vs VR	m C	s R	m C	m C	m C	m C	m RC	...	...	...	m C	vs C	...	...	...	l R	...	...	...	m C	...	m R	...	*	*	*	...	42.
43. —— aculeata, D'O.	...	...	...	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	l C	...	...	...	*	...	...	...	43.
44. —— ornata, D'O.	...	m C	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	44.
45. Lagena sulcata, W. & J.	s R	...	...	s R	...	s C	...	...	...	...	...	s R	...	...	...	...	...	...	...	...	l R	...	...	...	*	*	...	s R	45.
46. Entosolenia marginata, Montag.	s R	...	...	s R	s R†	m C	...	s C†	...	...	...	s R	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	*	s R	46.
47. —— squamosa, Montag.	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	...	...	...	s RC	...	...	...	...	...	...	...	...	...	...	47.
48. Polymorphina lactea, W. & J.	m C	...	...	...	...	...	...	...	...	...	...	m C	...	...	s R	s C	m C	...	...	m R	...	s C	m C	...	*	...	...	...	48.
49. —— tubulosa, D'O.	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	...	...	...	*	...	...	...	49.
50. —— Thouini, D'O.	...	...	...	m R	...	...	...	...	...	...	...	m RC	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	50.
51. Bulimina Pyrula, D'O.	...	...	l C	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	51.
52. —— marginata, D'O.	s R	m C	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	52.
53. —— aculeata, D'O.	...	...	m C	l C	...	...	s C	...	...	...	...	...	...	...	...	...	...	m RC	...	...	...	...	...	...	...	...	*	...	53.
54. —— pupoides, D'O.	s R	m C	m C	l C	...	m C	...	...	...	...	...	m C	s C	...	...	...	...	...	...	...	m C	m C	m R	...	*	...	*	...	54.
55. —— elegans, D'O.	...	...	...	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	m RC	...	...	...	...	...	...	...	...	...	...	55.
56. —— Buchiana, D'O.	s R	m C	...	l C	vl C	s C	s C	...	...	...	...	m C	s C	...	...	...	...	...	...	...	m C	...	...	...	*	...	...	...	56.
57. —— elegantissima, D'O.	vs C	...	...	l R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	57.
58. (Virgulina) squamosa, D'O.	...	...	m RC	s R	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	58.
59. (——) Schreibersii, Czjeck	...	...	...	...	...	...	...	...	...	...	...	l C	...	...	...	l C	...	l C	...	...	...	m C	m C	...	...	*	...	...	59.
60. (Bolivina) punctulata, D'O.	s RC	...	...	m C	s R	s R	s R	s C	vs C	...	...	m C	s C	...	...	...	...	s RC	...	...	m C	m C	...	*	*	...	*	...	60.
61. Uvigerina pygmæa, D'O.	s RC	m C	...	l C	l VC	m C	l C	l C	...	...	...	m C	s C	...	...	...	...	...	...	...	s C	...	...	...	*	...	...	...	61.
62. —— angularis, Will.	...	...	...	s R	...	m C	...	...	...	...	...	s C	s C	...	...	...	...	...	...	...	s R	...	...	...	...	...	...	...	62.
63. —— aculeata, D'O.	...	...	...	s R	m C	m C	s C	s R	...	...	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	*	*	...	...	63.
64. —— nodosa, D'O.	...	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	s C	m C	...	...	...	...	...	...	64.
65. Textularia agglutinans, D'O.	s C	...	m C	l C	...	s RC	s C	...	...	...	s R	l C	...	...	...	...	m RC	...	...	...	...	...	m C	...	*	...	...	...	65.
66. —— Turris, D'O.	...	...	...	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	66.
67. —— gibbosa, D'O.	...	m C	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	m RC	...	...	...	m C	m C	m C	...	*	...	*	...	67.
68. —— Trochus, D'O.	...	...	s R	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	l R	...	...	...	...	...	68.
69. —— abbreviata, D'O.	s R	...	...	m C	vs R	s R	s C	...	...	vs R	...	m C	...	...	...	...	...	...	...	...	m C	m C	m C	...	*	*	...	...	69.
70. —— Saggitula, Defr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	...	m RC	...	...	...	...	...	m C	...	*	*	*	...	70.
71. —— Partschii, Czjeck	...	...	...	m C	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	m R	...	...	...	...	*	...	...	71.
72. —— pygmæa, D'O.	s C	...	...	s C	...	s C	s C	s C	vs R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	72.
73. —— carinata, D'O.	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	73.
74. (Gaudryina) Badenensis, Reuss	...	...	...	vl C	l C	...	l RC	l RC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	74.
75. (Bigenerina) Nodosaria, D'O.	...	m C	m VC	l C	m C	m C	m C	...	...	...	...	l C	...	...	...	...	...	...	...	...	m C	...	m C	...	*	...	...	...	75.
76. (——) digitata, D'O.	...	l C	m VC	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	m RC	...	...	...	...	...	...	...	76.
77. (Grammostomum) Capreolus, D'O.	...	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	77.
78. (——) Gramen, D'O.	...	...	m VC	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	78.
79. (Verneuilina) tricarinata, D'O.	s R	...	...	m C	m C	m RC	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	79.
80. (——) spinulosa, Reuss	m RC	...	s C	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	m RC	...	...	...	m C	l C	...	...	...	*	...	80.
81. (——) polystropha, Reuss	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	81.
82. (——) communis, D'O.	...	m C	...	l C	l C	m C	m C	...	...	...	...	l C	...	...	...	...	...	...	...	...	m C	m C	...	...	*	...	...	...	82.
83. Orbitolina (Patellina) corrugata, Will.	s C	...	...	...	...	s C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	83.
84. —— lævis, P. & J.	...	...	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m R	...	...	m C	...	...	...	...	...	84.
85. Polytrema miniacea, Esper	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	85.
86. Spirillina vivipara, Ehrenb.	s RC	...	...	...	...	...	s RC	...	...	s VC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	86.
87. Trochammina inflata, Montag.	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	87.
88. —— squamata, P. & J.	...	...	...	...	...	...	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	88.
89. —— incerta, D'O.	...	...	...	l C	l C	s C	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	89.
90. —— charoides, P. & J.	...	...	...	m C	vs VC	s C	s C	s C	s RC	...	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	90.
91. —— clavata, P. & J.	...	...	...	m C	m VC	m RC	m VC‡	m C	m C	m R	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	91.
92. Valvulina angularis, D'O.	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	92.
93. Orbulina universa, D'O.	...	m C	m R	m C	l C	l C	l C	...	l C	l C	l VC	l C	...	...	...	...	...	...	...	...	m C	m R	l C	...	*	...	...	...	93.
94. Globigerina bulloides, D'O.	s R	m C	m R	l C	l C	l C	m C	m C	l C	l VC	l VC	m C	s VC	...	s VR	...	l R	s R	...	...	m C	s C	m C	l C	*	...	*	...	94.
95. —— helicina, D'O.	...	...	...	m C	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	95.
96. —— hirsuta, D'O.	...	...	...	...	...	l C	l C	...	l C	l C	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	96.
97. Planorbulina farcta, F. & M.	...	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	...	...	...	s C	l R	...	*	...	...	...	97.
98. —— Mediterranensis, D'O.	l C	...	s C	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	98.
99. (Truncatulina) lobatula, W. & J.	l C	m RC	m C	s C	s C	s R	s RC	s RC	...	...	...	m C	s C	...	m C	m C	...	m RC	...	s R	m C	m C	m C	m RC	*	...	...	...	99.
100. (——) refulgens, D'O.	...	m R	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	*	...	...	...	100.
101. (Anomalina) variolaria, D'O.	m C	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	101.
102. (——) coronata, P. & J.	...	...	...	m VC	...	m RC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	l C	...	l R	...	...	...	...	...	102.
103. (Planulina) Ariminensis, D'O.	...	l C	...	m C	m C	s C	s C	m RC	...	...	...	l C	...	...	...	...	...	...	...	...	l C	...	m C	...	*	*	*	...	103.
104. Rotalia Haidingeri, D'O.	...	m C	...	s C	s C	...	m C	...	...	...	...	m C	...	...	m C	...	m RC	...	...	...	l C	m C	m R	...	*	...	...	...	104.
105. —— Ungeriana, D'O.	...	m C	...	m C	m C	m C	...	s R	...	...	...	l C	vs C	...	...	...	...	...	...	...	...	...	...	s RC	*	...	*	...	105.
106. —— ammonoides, Reuss	...	l C	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	106.
107. —— reticulata, Czjeck	s R	...	...	...	...	...	m C	...	...	...	...	m C	m C	...	...	...	...	...	...	...	m C	m C	...	...	...	*	*	...	107.
108. —— Clementiana, D'O.	...	...	...	s C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	108.
109. —— Micheliniana, D'O.	...	...	...	m R	...	s R	m R	...	...	...	m R	...	...	...	...	...	...	...	...	...	...	...	l C	...	...	...	...	...	109.
110. —— repanda, F. & M.	m RC	...	m RC	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	...	*	...	...	...	110.
111. —— pulchella, D'O.	m RC	...	m RC	m C	...	s R	...	...	...	...	...	...	...	...	l R	...	...	...	...	...	...	...	...	...	...	...	*	...	111.
112. —— Menardii, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	112.
113. —— Antillarum, D'O.	...	s R	...	...	...	...	...	...	...	...	...	l C	...	...	...	...	l C	...	...	l RC	l C	...	...	...	*	...	...	...	113.
114. —— elegans, D'O.	...	l RC	m RC	...	m C	m C	s R	...	s VR	s R	...	l C	...	...	...	...	l C	...	...	l C	l C	...	...	...	*	*	...	...	114.
115. —— Schreibersii, D'O.	...	m R	...	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	115.
116. —— vermiculata, D'O.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	m C	m C	...	...	...	*	...	116.
117. —— Auricula, F. & M.	...	...	...	s R	...	...	...	...	...	...	...	m C	s C	...	...	...	...	l C	...	...	...	m C	...	...	*	...	...	...	117.
118. —— excavata, D'O.	...	...	...	...	...	...	...	...	...	...	...	l RC	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	118.
119. —— Beccarii, Linn.	l C	...	...	l C	s R	...	...	...	...	...	...	l C	...	s VC	l C	l VC	l C	l C	l C	...	s C	l C	l C	...	*	...	...	s VR	119.
120. —— ammoniformis, D'O.	m R	l VC	...	...	...	...	...	...	...	...	...	m R	...	...	...	m C	...	...	s R	...	...	...	...	...	...	...	...	...	120.
121. —— nitida, Will.	m C	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	121.
122. —— Soldanii, D'O.	...	...	...	m VC	m C	m C	m C	...	m C	m R	...	l C	...	...	...	...	...	...	...	...	l R	m R	...	...	*	...	...	...	122.
123. —— orbicularis, D'O.	...	...	...	m C	s C	s C	s C	s C	s C	vs C	...	...	vs C	...	...	...	...	...	...	...	...	l R	...	...	...	*	...	...	123.
124. (Calcarina) rarispina, Desh.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	124.
125. (——) armata, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	l R	...	...	...	...	...	...	125.
126. (——) excentrica, P. & J.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	m C	...	...	...	...	...	126.
127. Rotalia globularis, D'O.	m C	...	m C	...	s C	...	...	vs VR	s VR	...	s R	s R	...	...	m R	...	...	...	...	...	...	...	...	...	*	...	...	...	127.
128. —— Turbo, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	m C	...	...	...	*	...	128.
129. —— rosacea, D'O.	s R	s R	...	s R	...	...	...	...	...	...	s R	s R	...	...	m VC	m C	...	l RC	...	...	...	...	...	...	*	...	...	...	129.
130. —— semistriata, D'O.	s C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	130.
131. —— Bertholetiana, D'O.	s R	...	m C	s R	...	...	m RC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	s R	...	...	...	...	...	131.
132. —— elegans, D'O.	s VR	s R	s RC	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	m C	...	*	...	*	...	132.
133. Sphæroidina bulloides, D'O.	s VR	m C	...	m C	m C	s R	...	m RC	...	...	...	m C	...	...	...	...	...	...	...	...	m C	...	...	...	*	*	...	...	133.
134. Nonionina sphæroides, D'O.	s R	...	...	s R	...	s RC	s C	...	...	...	...	m C	...	...	...	...	...	...	...	...	s C	...	s R	...	*	...	...	...	134.
135. —— Scapha, F. & M.	m C	m C	...	...	...	...	...	...	...	...	...	m C	s C	...	...	m C	m RC	l C	...	...	m C	l C	...	...	*	...	...	...	135.
136. —— pompilioides, F. & M.	...	...	m VC	m C	...	s C	s C	...	s R	...	...	m C	s C	...	...	...	...	...	...	...	m C	...	...	...	...	...	*	...	136.
137. —— lævis, D'O.	m RC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	m RC	...	*	...	...	m C	137.
138. —— granosa, D'O.	m C	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	138.
139. —— limba, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	*	...	...	...	139.
140. —— asterizans, F. & M.	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	s R	...	l C	...	...	...	...	...	...	...	...	...	...	140.
141. —— stellifera, D'O.	m C	...	...	...	...	...	...	...	...	...	...	m C	s C	...	...	...	...	m C	...	...	s R	s R	...	...	*	...	...	s VC	141.
142. Polystomella striatopunctata, F. & M.	m C	m C	...	...	...	...	...	...	...	...	...	s R	...	...	...	...	...	...	...	...	...	...	s R	...	...	...	...	l VC	142.
143. —— macella, F. & M.	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	143.
144. —— Fichteliana, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	vl C	m RC	...	...	...	...	m C	...	...	...	...	l VC	144.
145. —— unguiculata, Gmel.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	l VC	145.
146. —— crispa, Linn.	m C	m C	m VC	s R	...	vs R	vs VR	...	vs VR	...	s VR	l C	...	...	l C	l C	m C	m RC	...	l VC	m C	l C	m C	...	*	*	*	l VC	146.
147. Amphistegina vulgaris, D'O.	...	§	...	...	...	...	...	...	...	...	...	...	...	...	m VC	...	m C	m RC	...	l VC	s VR	...	m C	...	*	...	...	...	147.
148. Heterostegina depressa, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	l C	*	...	...	...	148.
149. Operculina complanata, Bast.	...	...	...	vs RC	...	...	s R	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	*	...	...	...	149.
150. Nummulina planulata, Lam.	...	...	...	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*	...	150.
151. Cassidulina lævigata, D'O.	s R	...	m RC	s RC	...	...	s R	...	...	...	...	s C	s C	...	...	...	...	...	...	...	...	...	m R	...	*	...	...	...	151.
152. —— crassa, D'O.	...	...	...	s RC	...	s C	s C	vs C	vs R	...	...	m R	...	...	...	...	...	...	...	...	...	...	...	...	*	...	*	...	152.
153. —— oblonga, Reuss	...	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	153.
154. Spiroloculina planulata, Lam.	l C	...	l C	l C	...	...	...	...	...	...	...	...	s C	...	l C	...	m RC	...	...	...	...	...	l C	...	*	...	...	...	154.
155. —— limbata, D'O.	l C	...	...	...	...	...	s C‖	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	l C	...	*	...	...	m R	155.
156. —— striata, D'O.	m R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	156.
157. —— canaliculata, D'O.	m R	...	m C	l C	m C	...	...	...	...	...	...	m C	...	...	...	m C	m RC	m C	m C	...	s R	...	m RC	...	*	...	*	...	157.
158. Quinqueloculina Seminulum, Linn.	l C	m C	m C	...	...	s R	s R	...	vs RC	...	...	m C	s C	...	...	...	...	m C	...	...	...	...	...	...	*	...	*	...	158.
159. —— agglutinans, D'O.	m C	m C	...	m C	...	m RC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	159.
160. —— vulgaris, D'O.	l C	...	...	l C	...	...	...	...	...	...	...	l C	...	...	...	...	...	...	...	...	...	...	l C	...	...	...	*	...	160.
161. —— pulchella, D'O.	m RC	...	l VC	l RC	s C	...	...	...	...	...	...	l C	...	...	...	...	...	l C	...	...	l R	s R	l C	...	*	...	*	...	161.
162. —— triangularis, D'O.	m RC	...	s R	s C	...	...	...	...	...	...	...	...	...	...	...	...	m RC	...	...	...	...	...	l C	...	*	...	...	...	162.
163. —— Lyra, D'O.	...	...	m R	...	...	...	s C	...	...	...	...	...	...	...	...	...	...	l C	...	...	s R	...	...	...	...	...	*	...	163.
164. —— tenuis, Czjeck	...	...	...	s C	s C	s C	s C	...	...	...	...	...	s C	...	...	...	...	m C	...	...	...	...	...	...	*	*	*	...	164.
165. Triloculina trigonula, Lam.	...	s C	...	...	...	...	vs C	vs VC	...	...	...	...	...	...	l C	...	m RC	m C	...	...	...	l C	...	...	*	...	*	...	165.
166. —— Brongniartii, D'O.	m RC	m C	m RC	l RC	...	...	s C	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	l C	...	*	...	*	m C	166.
167. —— oblonga, Montag.	m C	m C	s C	s R	s C	vs C	...	...	...	s R	s R	...	...	...	...	...	...	...	...	...	...	...	l R	...	*	...	...	m C	167.
168. —— reticulata, D'O.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	168.
169. —— tricarinata, D'O.	m R	...	...	...	...	vs R	s C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	169.
170. Biloculina ringens, Lam.	...	m C	...	l VC	l C	m C	s C	...	...	...	...	...	...	...	...	...	...	s C	...	s R	...	...	m RC	...	*	...	*	...	170.
171. —— elongata, D'O.	...	m C	...	m R	...	s C	s C	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	*	...	...	...	171.
172. —— depressa, D'O.	...	...	m C	s C	...	...	s C	...	...	...	...	l C	...	...	...	...	...	...	...	...	l R	...	...	...	...	...	*	...	172.
173. Hauerina compressa, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	173.
174. Vertebralina striata, D'O.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	174.
175. —— Cassis, D'O.	...	...	...	...	...	...	s VR	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m R	...	*	...	...	l C	175.
176. —— inæqualis, Gmel.	...	...	...	...	...	...	vs RC	...	vs RC	vs RC	...	...	...	...	...	...	...	...	...	...	...	...	l C	...	...	...	...	m R	176.
177. Nubecularia lucifuga, Defr.	l C	l R	...	...	...	...	...	m RC	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	177.
178. Cornuspira foliacea, Phil.	s C	...	vl C	m C	s R	...	...	...	...	...	...	m RC	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	178.
179. Lituola nautiloidea, Lam.	...	...	vs R	...	...	...	...	...	...	...	...	vl C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	179.
180. —— Canariensis, D'O.	...	...	s C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	180.
181. —— pelagica, D'O.	...	...	s C	s C	...	s C	s C	...	vs C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	181.
182. —— Cenomana, D'O.	...	...	...	m C	...	...	m C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	182.
183. —— Scorpiurus, Montf.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m C	...	...	...	...	...	...	...	183.
184. —— Soldanii, P. & J.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	184.
185. Peneroplis planatus, F. & M.	l C	¶	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	185.
186. —— cylindraceus, Lam.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	186.
187. (Dendritina) Arbuscula, D'O.	l C	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	187.
188. Orbitolites complanata, Lam.	s C	...	s R	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	188.
189. Orbiculina adunca, F. & M.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	...	...	...	189.
190. Alveolina Melo, D'O.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	*	*	...	...	190.
191. Dactylopora reticulata, Defr.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	m R	...	...	...	...	...	...	...	...	...	191.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	

† Some beautiful Calcarine or aculeate varieties. ‡ A single specimen of another variety (*T. alternans*, P. & J.) also occurs here.

§ Fossil specimens derived from the Tertiaries occur here, and so do fossil specimens of other Foraminifers (*P. crispa*, &c.) which exist here recent. ‖ A beautiful circular variety, *Sp. rotundata*, D'O. ¶ Plancus.

31. *Marginulina Lituus*, D'Orb. Ann. Sc. Nat. vii. p. 259, No. 11; Soldani, Testaceog. i. pt. 2, pl. 106. fig. *aa, bb*.

43. *Cristellaria aculeata*, D'Orb. Ann. Sc. Nat. vii. p. 292, No. 14; Soldani, Testaceog. i. pt. 1, pl. 57. fig. *tt*; *C. echinata*, D'Orb. For. Fos. Vien. pl. 4. f. 21, 22.

51–60. The genus *Bulimina* comprehends all the forms here indicated. *Virgulina* is a delicate, compressed, biserial *Bulimina*, the chambers not increasing with exact regularity. *Bolivina* is a similar form, but more regularly plaited in its growth, being a Textularian isomorph. All these lie within the limits of an essential species.

53. *Bulimina aculeata* D'Orb. Ann. Sc. Nat. vii. p. 269, No. 7; Soldani, Testaceog. i. pt. 2, pl. 127. fig. I, pl. 130. f. VV.

64. *Uvigerina nodosa*, D'Orb. Ann. Sc. Nat. vii. p. 269, No. 3; Soldani, Testaceog. i. pt. 2, pl. 126. fig. *xx, yy, zz*, A, B.

65–82. *Textulariæ*. Varieties of one manifold species, belonging to one generic type. The shell of *Gaudryina* commences with three cells in a coil, before it takes on its biserial Textularian character. Such as take on a uniserial growth have been termed *Clavulina*, and confounded with similar varieties of *Valvulina*. The arrested triserial growth is *Verneuilina*. *Bigenerina* is a *Textularia* becoming uniserial. *Grammostomum* is a compressed form of *Textularia*, with a terminal slit-like aperture. This kind of aperture passes gradually, on the one hand, into the common arched passage of *Textularia*, and on the other into the round terminal aperture of *Bigenerina*. *Grammostomum* also may be dimorphous,—passing from the complex to the simple arrangement of cells.

82. *Verneuilina communis*, D'Orb. This is the *Clavulina communis*, D'Orb. For. Foss. Vien. p. 196, pl. 12. f. 1, 2. For some remarks on the several forms referred to *Clavulina* by authors, see Annals Nat. Hist. 3 ser. vol. v. p. 469.

83, 84. The characters and relationship of *Orbitolina* and *Patellina*, with their numerous varieties, are explained in the Annals Nat. Hist. 3 ser. vol. vi. pp. 29–38.

85. *Polytrema miniacea*, Esper, sp.* *Millepora miniacea*, Esper, Zooph. i. pl. 17; Gmel. Syst. Nat. 3784; *M. rubra*, Lamarck, Hist. An. s. Vert. ii. p. 202, No. 8; *Polytrema corallina*, Risso, Europe Méridion. v. p. 340, No. 91; *Polytrema miniacea*, Blainville, Actinolog. p. 410, pl. 69. f. 4. This is a fixed, reddish, often branching Rhizopod, related to *Orbitolina*.

86. *Spirillina vivipara*, Ehrenb. See Annals Nat. Hist. 2 ser. xix. p. 284. This has been often confounded with other *Foraminifera*, similarly shaped, but with sandy and opake shells, and of distinct relationship. *Sp. vivipara* is related to *Rotalia* through the simple vermiculate varieties of *R. repanda*, especially *R. vermiculata*.

* We have to thank Dr. J. E. Gray for pointing out the synonymy of this species.

88–91. *Trochammina.* We have elsewhere* expressed an opinion that the *Rotalia inflata* of Montagu belongs to a subgenus distinct from the common *Rotaliæ.* The study of more varieties than we were then acquainted with leads us to regard it as generically distinct. The sandy structure, great variability of shape, and the more or less imperfect formation of the chambers, are important characters of this genus, which we have termed *Trochammina.*

The shell consists of a dense ferruginous cement filled with small sand-grains which do not project above the surface. It resembles a worked plaster-surface. It differs from the shell of *Nubecularia,* in which the sand, when present, roughens the surface, but is often absent; and from that of *Lituola* where the sand is in greater proportion than the cement, and is very coarse.

The simplest forms of *Trochammina* belong to a species (*T. irregularis,* D'Orb. sp.) of which we know three varieties. First, *T. irregularis* proper (*Webbina*† *irregularis,* D'Orb., Prodrome, ii. p. 111; Bronn, Leth. Geog. 3rd edit. ii. pt. 5. p. 91, pl. 291. f. 27; "Œufs des Mollusques," Cornuel, Mém. Soc. Géol. France, 2 sér, iii. p. 259, pl. 4. f. 37‡), which is adherent, moniliform, with more or less oval chambers, and varying in the relative length of the stoloniferous connecting tubes, in the number of the chambers, and in the straightness or curvature of their line of growth.

Secondly, *T. irregularis alternans,* which is adherent and has the stolons springing from the chambers alternately and towards their front, giving the shell a loose Textularian character. The chambers are usually somewhat pyriform.

Thirdly, *T. irregularis clavata,* which is another fixed form, and consists frequently of a single pyriform chamber, tubular at one end, and bearing a slightly margined and semioval aperture at the other. The tubular portion frequently gives off another tube and chamber. This bifurcation is also occasionally seen in *T. irregularis* (from the Oxford clay); nor is it wanting in low forms of *Nodosaria* (*Dentalina aculeata,* D'Orb.).

The second species, *Trochammina squamata,* comprises five varieties, which are spiral, and more or less Rotalian, in their growth.

The simpler of these forms, such as *T. squamata incerta* (*Operculina incerta,* D'Orb. For. Cuba, pl. 6. f. 16, 17; *Spirillina arenacea,* Williamson, Monograph, p. 93, pl. 7. f. 203), consist of a long spiral undivided chamber, having the shape of the clear, perforated, discoidal *Spirillina vivipara,* Ehrenb., and of the white, opake, Milioline *Cornuspira foliacea,* Philippi.

T. squamata charoides is a similar undivided tubular chamber vertically spiral (instead of being complanate), and presents a curious resemblance to the fruit of the *Chara.*

The third variety, *T. squamata gordialis* (from the Indian and

* Annals Nat. Hist. 3 ser. iv. p. 347.

† The name *Webbina* was first applied by D'Orbigny to a few-chambered, uniserial, curved form of *Nubecularia* (*Webbina*) *rugosa,* For. Canaries, pl. 1. f. 16–18, and For. Foss. Vien. p. 74, pl. 21. f. 11–12.

‡ Fig. 36 is *Lituola* (*Placopsilina*) *cenomana.*

Arctic Seas), has more than one chamber, the shell in its early stage being formed of a few spirally arranged but variable chambers; and at a later period being moulded on an undivided, vermiform sarcode, either discoidal or irregularly elevated; sometimes passing at nearly right angles over the disc, or forming sudden loops and twistings*.

T. squamata proper has the shell divided throughout into lunate and flattened chambers, several in a whorl, and regularly increasing with the progress of growth. It much resembles those flatter varieties of *Rotalia Turbo* which are intermediate between *R. globularis* and *R. rosacea*. *T. squamata* may easily be confounded with little, conical, scale-like varieties of *Valvulina triangularis*; but the latter (more nearly allied to the Verneuiline *Textulariæ*) have never more than three chambers in a whorl, and are more coarsely sandy.

T. squamata inflata (*Rotalia inflata*, Montagu) has been already described (Ann. Nat. Hist. *loc. cit.*).

92. *Valvulina angularis*, D'Orb. *Clavulina angularis*, D'Orb. Ann. Sc. Nat. vii. p. 102, pl. 12. f. 7. The chief distinctive feature of this Clavuline form is the lingual process, or valve, partially occluding the aperture,—a characteristic of *Valvulina*.

94. *Globigerina helicina*, D'Orb. Ann. Sc. Nat. vii. p. 277, No. 4; Soldani, Testaceog. i. pt. 2. pl. 130. fig. *qq, rr, pp, p*.

97–108. These are varieties of *Rotalia* (*Planorbulina*) *farcta*, F. & M.

109–118. Varieties of *Rotalia repanda*, F. & M.

114. *Rotalia elegans*, D'Orb. Ann. Sc. Nat. vii. p. 276, No. 54; Soldani, Saggio Orit. pl. ii. f. Q, R; *Rotalia Partschiana*, D'Orb. For. Foss. Vien. pl. 8. f. 1–3. This is a variety of *R. repanda*.

116. *Rotalia vermiculata*, D'Orb. *Planorbulina vermiculata*, D'Orb. Ann. Sc. Nat. vii. p. 280, No. 3; Soldani, Testaceog. i. pt. 3, pl. 161. fig. A B C D. This flat few-celled Spirilline *Rotalia*, resembling the Planorbuline forms of *R. farcta* merely in outline and flatness, passes gradually into the *R. repanda* by regular gradations, especially through *R. pulchella*; and differs in structure and habit very markedly from every variety of *Rotalia* (*Planorbulina*) *farcta*.

118. *Rotalia excavata*, D'Orb. *Valvulina excavata*, D'Orb. For. Canaries, pl. 1. f. 43–45. The lobular process of the chamber (common in varieties of *R. repanda*), which has nothing in common with the lingual plate of sandy *Valvulina*, has caused this form to be mistaken for a *Valvulina*. The shell is essentially Rotalian in its structure.

119–123. These are varieties of *Rotalia Beccarii*, Linn.

120. *Rotalia ammoniformis*, D'Orb. Ann. Sc. Nat. vii. p. 276, No. 33; Soldani, Testaceog. i. pt. 1, pl. 34. fig. *K*.

* The *Serpula pusilla* of Schlotheim (*Spirillina pusilla*, Jones), from the Permian limestones of Durham and Germany, is probably closely related to this form.

124–126. These are varieties of *Rotalia* (*Calcarina*) *Spengleri*, Gmelin.

126. *Calcarina excentrica.* This is a peculiar, and not previously described variety of *C. Spengleri*, attaining a relatively large size (that of half a mustard-seed). It commences its growth as a little *Rotalia*, scarcely distinguishable from *R. armata*, which is a small variety of *C. Spengleri*. Each cell grows out into a projecting angle, giving a dentate margin to the shell. At first spirally discoid, this *Calcarina* soon begins to grow all on one side, producing a subtriangular or fan-shaped mass; the apex consisting of the first few spiral chambers; the base being notched in outline, and broadening with a cyclical tendency. Beyond this stage a further growth of cells would produce a complanate cyclical shell. *Planorbulina farcta* presents at one stage of its growth a plan of growth like that of *C. excentrica*, and at a later period such a cylical arrangement as that above referred to.

127–132. Varieties of *Rotalia Turbo*, D'Orb.

128. *Rotalia Turbo*, D'Orb. Here represented by *R. Patella*, Reuss, Denkschr. Akad. Wien, i. pl. 46. f. 22, which is evidently a small form of *R. Turbo*.

132. *Rotalia elegans*, D'Orb. *Anomalina elegans*, D'Orb. Ann. Sc. Nat. vii. p. 282, No. 4; Modèles, No. 42; *Rosalina complanata*, D'Orb. For. Foss. Vien. pl. 10. f. 13–15. This is a variety of *R. Turbo*.

134. *Nonionina sphæroides*, D'Orb. This differs from the other *Nonioninæ* (which are varieties of *Polystomella*), and indeed it appears to be more nearly related to *Globigerina* than to *Polystomella*. It has fewer chambers than any common *Nonionina*, and its low arched aperture is very much wider; its substance is dense, clear, finely porous, and highly polished (except at the margins of the aperture, which are granular). By these features, and by the setting on of the chambers, it is markedly distinguished from *Nonionina*, and probably deserves another appellation; but until its relationship to the deep-sea varieties of *Polystomella* and to the abyssal species *Globigerina* and *Sphæroidina* shall have been worked out more fully, we prefer leaving it with its present name. Large varieties of *N. sphæroides* occur at great depths (2200 fathoms, Indian Ocean, &c.), and often present a want of symmetry in the spiral form.

135–146. We have shown elsewhere* that the *Nonioninæ* are feebly developed *Polystomellæ*. The varieties here enumerated present a fair example of the increase of complexity in form and structure from *N. Scapha* to *P. crispa*. Carried still further, the peculiarities of structure are exaggerated in the typical *P. craticulata*.

* Annals Nat. Hist. 3 ser. vol. v. pp. 101–103.

154–173. These are *Miliolæ* not separable specifically from the type, *Miliola Seminulum*, Linn.

155. *Spiroloculina limbata*, D'Orb. Ann. Sc. Nat. vii. p. 299, No. 12; Soldani, Testaceog. ii. pl. 19. fig. *m*.

160. *Quinqueloculina vulgaris*, D'Orb. Ann. Sc. Nat. vii. p. 302, No. 33; Soldani, Testaceog. i. pt. 3, pl. 152. fig. E; *Q. secans*, D'Orb. Ann. Sc. Nat. p. 303, No. 43; Modèles, No. 96; Soldani, Testaceog. i. pt. 3, pl. 152. fig. C.

161. *Q. pulchella*, D'Orb. Ann. Sc. Nat. vii. p. 303, No. 42; Soldani, Testaceog. ii. pl. 18. fig. F; *Q. Schreibersii*, D'Orb. For. Foss. Vien. p. 296, pl. 19. f. 22–24.

168. *Triloculina reticulata*, D'Orb. Ann. Sc. Nat. vii. p. 299, No. 9; Soldani, Testaceog. i. pt. 3, pl. 159. fig. *bb*, *cc* (by error quoted *ee*, *ff* by D'Orbigny).

170. *Biloculina elongata*, D'Orb. Ann. Sc. Nat. vii. p. 298, No. 4; Soldani, Testaceog. i. pt. 3, pl. 153, fig. M, Q, *p*.

184. *Lituola Soldanii*. New variety. [Type: *Lituola nautiloidea*, Lamarck.] This is a relatively large and straight *Lituola*, having the shape of a *Nodosaria*. It has a variable number of chambers, from about four to eight, each much subdivided and labyrinthic, as is the case also in the large crozier-shaped variety that occurs in the Chalk. Soldani has figured this straight subcylindrical *Lituola* (Testaceog. ii. pl. 3. fig. *cc*; and Saggio Orittog. pl. 19. fig. 92 Z), from San Quirico. Our finest specimens of this variety are from the Miocene sandy clays of San Domingo. It occurs recent at a depth of 40 and 47 fathoms off the Abrolhos Bank (Lat. 23°07′S.; Long. 41°17′W.). The deposits on this bank have peculiar faunal analogies with the Italian Tertiaries.

January 18, 1860.

James Poyntz M'Donald, Esq., Kingsdown Parade, Bristol; William Purdon, Esq., C.E., Punjab; and James Winter, M.D., Hampstead, were elected Fellows.

The following communications were read:—

1. *Notice of some* Sections *of the* Strata *near* Oxford.

By John Phillips, M.A., F.R.S., Pres.G.S., Reader in Geology in the University of Oxford.

No. II. *Sections South of Oxford.*

In England, unconformity between the Cretaceous and the Oolitic strata is discoverable at almost every part of the range of the junction

of deposits, from the coast of Yorkshire to the cliffs of Dorsetshire. Everywhere evidence can be found of the wasting action of the sea on the Oolitic strata before the deposition of the superincumbent rocks, and sometimes evidence of the movement of the sea-bed (to which, perhaps, the watery agitation was due). In the country near Oxford, and from this point south-westward, the Portland Oolite has been thus greatly wasted, so as to remain in only a few detached masses. There seems reason to suppose that movements of the sea-bed of considerable extent followed the deposition of the Oxford Clay; for the Coralline Oolite fails, and the Kimmeridge Clay grows thin, and hardly traceable far from the Shotover Hills, in a direction towards the north-east.

The deposition of the Cretaceous series on the wasted Oolites was thus inevitably irregular; but in addition we have the varieties of littoral, estuary, and fluviatile deposits on the boundary-surface of the Oolites; great surface-waste, referable to the Postpliocene age; and faults which seem to be of great effect, but are not yet traced out.

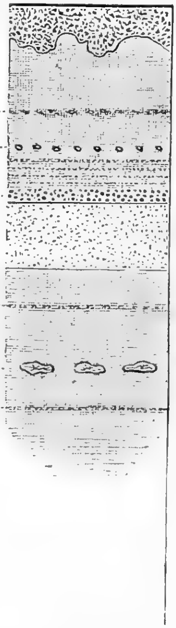
Under these circumstances, it is at once a very interesting and a very perplexing problem of field-geology to trace out the detached, unconformed, and wasted cappings of sand and ferruginous stone which, in several places, lie on the Kimmeridge Clay, and are not themselves covered by strata of more definite character and age.

The conclusions derived from the field-surveys will not be satisfactory until fully supported by the evidence of fossils scrupulously collected by careful hands.

One of the most interesting of the sections near Oxford is seen at Culham, on the northern bank of the Thames; and this may be compared with another in the line of railway near Culham Station, about a mile to the north-east, with a hill-capping at Toot Baldon and a cliff-section at Clifden. I have been in the habit of taking my class to some of these localities for several years.

On entering the excavation at Culham we perceive about 40 feet of level-surfaced clays and sands, under a cover of flint-gravel mixed with worn shells of *Gryphæa dilatata* and other spolia of the adjacent country. Nearly the whole mass of the clays and sands excavated here is employed for brick-making; and the digging-operations mix them much together. A slight glance at the section presents enough of uniformity to induce the belief that the whole might belong to one continuous deposit. If, under this impression, a palæontologist viewing the excavation should pick up *Thracia depressa* and *Cardium striatulum*, and obtain from the workmen teeth of *Pliosaurus*, he will probably write Kimmeridge Clay on the whole section. Another geologist, arriving when the clay is not being dug, may examine a different part of the deposit and find *Ammonites dentatus* and *Belemnites minimus*, and may colour on his map, undoubted Gault. But when, instructed by several visits, the whole section is clearly made out, we find two clays in the pit, of entirely different geological age, separated by a bed of sand apparently conformed to each—so far as this very limited area gives any evidence.

Section of the Strata at Culham, South of Oxford.



In descending from the gravelly surface-deposit, we have about 10 feet of blue laminated clay, with the following fossils:—

Ammonites dentatus.	Nucula pectinata.
Ammonites lautus.	Inoceramus concentricus (large).
Belemnites minimus.	Plicatula pectinoides.
Solarium conoideum.	Pecten quinquesulcatus.
Rostellaria.	Balanus.
Dentalium, probably *D. decussatum*.	Cyclocyathus Fittoni.

Coniferous wood.

Below these unequivocal Gault layers, the argillaceous deposits are striated with short drift laminæ of sand and small gravel. In these, by careful search, I found specimens of the *Ammonites* mentioned above. These layers are about 5 feet thick, and gradually pass upward into the ordinary Gault*.

Below these sandy layers is a more specially pebbly band, in some places compacted together, in which I found what seems to be *Pecten orbicularis*. This band agrees in position with what may be termed the basement bed of the Gault or the cap of the Lower Greensand at Folkestone †.

* In this part of the series, probably, occurred a fine specimen of *Ostrea macroptera*, which came into the hands of my friend Professor Walker, who resides at Culham.

† Since the reading of this paper, my friend Mr. Clutterbuck has found in

Passing over for the present the bed of greensand, 9 feet in thickness, which lies under the pebbly bed, and turning to the subjacent clay, which is exposed to a depth of 23 feet in the course of the digging, we find it to contain, especially towards the upper part,—

Pliosaurus of Shotover.
Ichthyosaurus of Shotover.
Asteracanthus ornatissimus.
Ammonites—one species of the group of *A. polyplocus*, *A. triplicatus*, or *A. giganteus*.
Ammonites biplex.
Cardium striatulum.
Thracia depressa.
Astarte Hartwelliensis.
Cucullæa.
Perna.
Discina Humphreysiana.

Towards the bottom of the excavation lies a layer of brown cracked nodules, the cracks partly filled with bisulphuret of zinc. The Ammonites and other fossils occur again below the nodules. No specimen of *Ostrea deltoidea* being found here, but the shells of Aylesbury being abundant, we may infer that it is the upper part of the Kimmeridge Clay which is here seen.

The bed of greensand, 9 feet thick, which separates these two clays, may now be considered. The mineral character of such a deposit is such feeble evidence, that without injustice to that the sand may be referred to any part of the series between the Kimmeridge Clay and the Gault. In appearance, however, it is like some of the dark-green sand-beds at the back of the Isle of Wight (as at Blackgang Chine), and it is not like the Portland Sand or the Iron-sands of Shotover. I find in it none of the fossils of the Gault above, nor any common fossils of the Portland rock or sands, but a few examples of the Ammonite like *A. polyplocus* already mentioned in the Kimmeridge Clay, *Cardium striatulum*, *Thracia depressa*, *Pecten arcuatus*, *Corbula*, and Wood. I do not find a trace of these fossils in the pebbly drifts above, and do not suppose them to have been transported from older strata into this greensand. On further search I discover no sign of unconformity at the junction of the sand with the subjacent clay, nor any mark of wasting on that clay; but, on the contrary, a somewhat gradual introduction of the sandy grains, so as to make an easy passage upwards from clay to sand. I am therefore induced to believe that instead of this being, as at first sight it might be thought, Lower Greensand, it is really a sandy cap of the Kimmeridge Clay—perhaps the first stage of a change towards the Portland series, but still to be classed with the clay.

The information thus gathered from the section now discussed may be increased by observing what occurs in the railway-cutting a mile to the north-east of the Brickyard. According to the working-section prepared by the engineer, Mr. Ward *, it appears that the Gault is there found resting *unconformably* on ferruginous sands

this band a specimen of *Exogyra* resembling *E. haliotidea*, which somewhat strengthens my opinion that this thin layer is all that here represents the Lower Greensand. It thickens towards the westward, retaining its worn sandy and pebbly character. Possibly other observers may prefer to separate from the Gault the five feet of sandy and pebbly layers, and call them Lower Greensand; but this is not my conclusion.—April 11, 1860.

* I am indebted to Mr. Clutterbuck for the sight of this section.

apparently corresponding with those of Shotover; and these rest on the Kimmeridge Clay, but grow thinner and die out to the southward.

Another example of a sandy deposit covering the Kimmeridge Clay occurs at Toot Baldon, a village elevated above the general plain of Kimmeridge Clay, and lying four miles north-east of Culham. Here, some years since, on the very summit I found sandy and stony beds in small quantity and not well exposed. They yielded me no fossils; but my friends of the Geological Survey have since visited the locality, and obtained an Ammonite which they believed to be of the group of *A. Deshayesii* *. I lately re-examined the spot, now less exposed than ever, without finding anything satisfactory. But on proceeding down the sloping road to the eastward, I perceived the clay to be there also covered by ferruginous bands, and commenced a persevering search for fossils. I made a considerable excavation, and obtained several shells, especially a *Mya*, *Pecten*, *Cardium*, *Trochus*, and an Ammonite which appears to be of the group of *A. polyplocus*, *A. triplicatus*, and *A. giganteus*.

The mass is sand and sandstone with small black pebbles, and stained very brown by oxide of iron. It rests immediately on the Kimmeridge Clay, probably on the very top or upper layers. In the hope of revisiting this place and of obtaining more and better evidence, I abstain from further remarks.

A remarkable exhibition of a sand-rock with pebbles occurs in cliffs against the Thames at Clifden Ferry. It is traversed by oxide of iron in nests, laminæ, and veins running in various directions. As far as the composition of the mass is concerned, this sand-rock resembles somewhat the Shotover irony rocks, and somewhat the pebbly Lower Greensand of Farringdon; but no fossils have been found in it.

From what has been said it is evident that I regard as still doubtful and incomplete the evidence according to which Lower Greensand deposits have been admitted to occupy large areas on the maps of the country near Oxford. The evidence from fossils (certainly of paramount importance in deciding between sands of such variable types as those between the Kimmeridge Clay and the Chalk) is either wanting or appears opposed to the claim of large territory for the Lower Greensand. Dr. Fitton quotes no fossils near Oxford, and only casts of *Siphonia* and Coniferous wood from the iron-sands of Bedfordshire; and the Geological Survey has had only a glance at an Ammonite, which was supposed to be *A. Deshayesii*, on the summit of a hill near Oxford, from which I obtained quite a different Ammonite, apparently of an Oolitic group, with other shells not such as to authorize the adoption of their sandy matrix into the Cretaceous family.

* Mr. R. Etheridge has obliged me with this notice of his search.

2. *On the Association of the Lower Members of the* Old Red Sandstone *and the* Metamorphic Rocks *on the* Southern Margin *of the* Grampians. By Prof. R. Harkness, F.R.S., F.G.S.

[Abstract.]

The area to which this paper referred is the tract lying between Stonehaven and Strathearn, including the south-eastern flanks of the Grampians for about two-thirds of their course. Metamorphic rocks, trap-rocks, the Lower and Middle members of the Old Red series (the former being sandstone, and the latter conglomerate), are the constituent rock-masses of the district, and give it its peculiar physical features. The mode in which these rocks are associated is well exhibited in the section on the coast (at Stonehaven), and in the several sections in the interior where streams lay bare the rocks. Sections at Stonehaven, Glenburnie, Strathfinlass, North Esk, West Water of Lethnot, Cruick Water, South Esk and Prosen, Blairgowrie, Dunkeld, Strathearn, and Glenartney, were described in detail.

Against the north-westerly dipping metamorphic schists (which sometimes include conformable limestones) come purple flagstones, but usually separated from them by trap-rocks, having the same strike. These flagstones pitch to the south-east, but retain a high angle away from the schists, and, in many places, are intercalated with beds of trap. The lower purple flagstones are unfossiliferous; but higher up tracks of Crustaceans (*Protichnites*) have been discovered by the Rev. H. Mitchell. The grey fossiliferous flagstones of Forfarshire succeed, still with a steep dip. Conglomerates succeed, in beds having a less inclination, gradually becoming more and more horizontal as they reach the low country.

The axis of the elevation of the Grampians thus appears to be along their southern margin, and to be marked by the trap-rocks separating the metamorphic schists and the purple flagstones of the Old Red series, and giving the latter their general south-easterly dip. As the metamorphic rocks of the Grampians have not yielded any fossils, their relation to the other old rocks of Scotland is difficult to determine.

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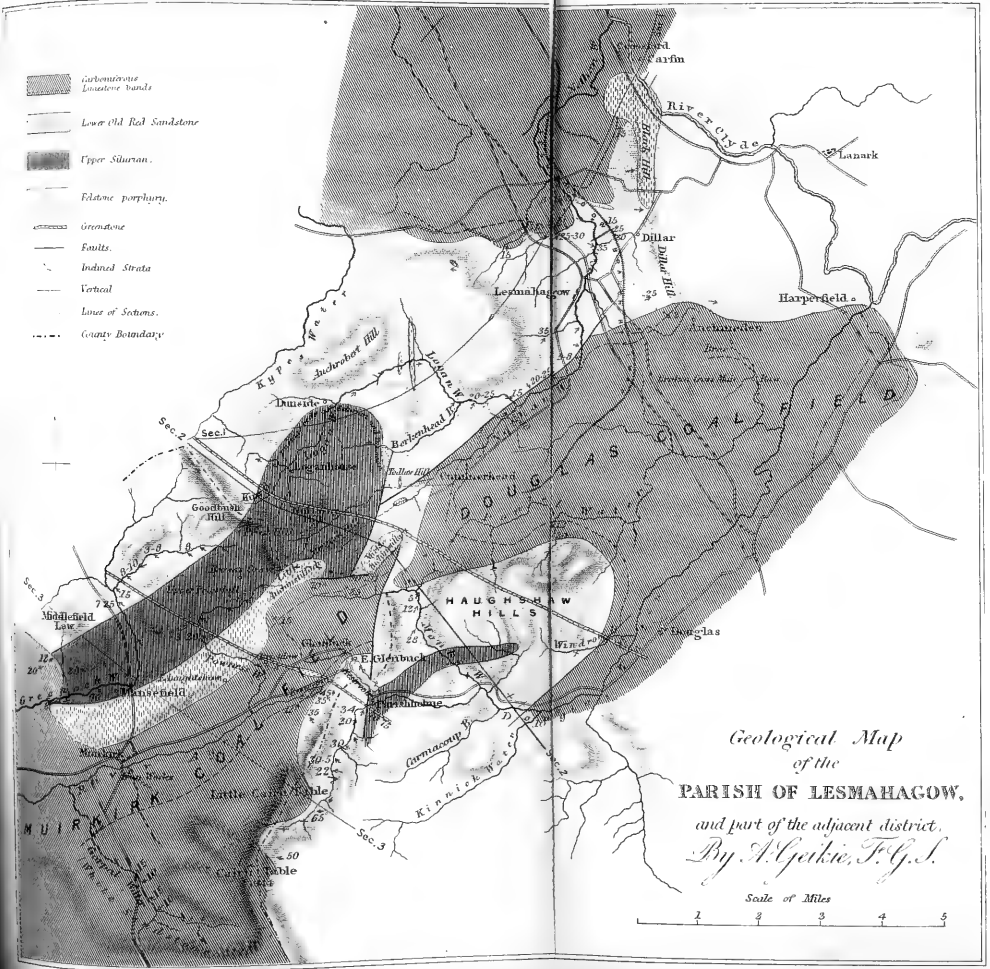
3. *On the* Old Red Sandstone *of the* South of Scotland. By Archibald Geikie, Esq., F.G.S., of the Geological Survey of Great Britain.

[Plate XVIII.]

Contents.

Introduction.—During the last summer, while carrying on the Geological survey of the Lammermuir Hills, I was particularly

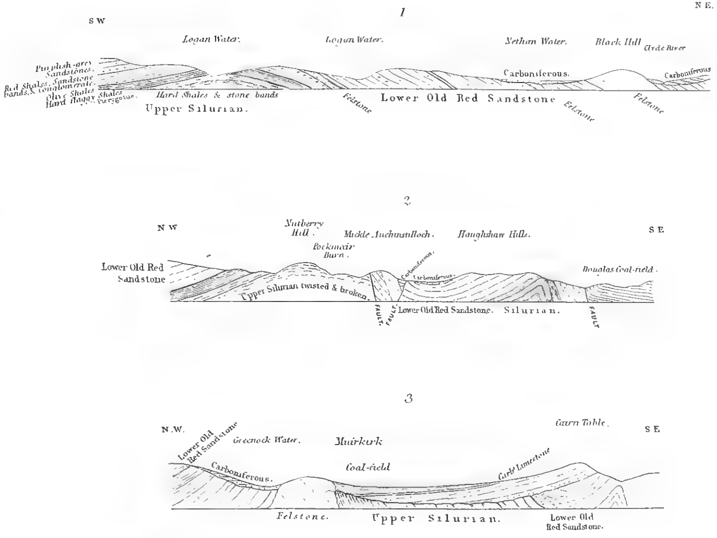

Purplish
Sands.
Shales, Sand
Olive
Hard
Sec. 3
M U
W. Lowry



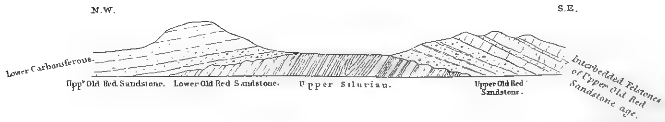
Geological Map of the
PARISH OF LESMAHAGOW,
and part of the adjacent district.
By A. Geikie, F.G.S.

Sections explanatory of the Geology of Lesmahagow, by A. Geikie, F.G.S.

1. 2. 3. Sections across the Parish of Lesmahagow.



4. Section of the Pentland Hills South end.



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struck with the number of felspathic dykes by which the Silurian strata of that region are intersected. It was my wish to ascertain, if possible, the probable date of these igneous rocks; and for this purpose it became necessary to determine the exact relation between the Old Red Conglomerates and Sandstones of East Lothian, and the Old Red Sandstone and Upper Silurian in other parts of South Scotland. I soon perceived, however, that the determination of this point had a much wider range than at first sight appeared, and that in truth it bore directly upon the question of the true classification of the Old Red Sandstone. The district which promised to afford the most satisfactory results was the Parish of Lesmahago, where, according to the section by Sir Roderick Murchison*, an ascending series could be made out from the Upper Silurian, through the Old Red Sandstone, into the Carboniferous group. I visited Lesmahago, and mapped the boundary-lines of the Lower Old Red Sandstone and Carboniferous rocks over an area of from 80 to 90 square miles. The results of this examination, in so far as they bear on the Old Red Sandstone, form the first and principal part of the present communication. I shall next refer to the extension of the Lesmahago features to the north-east, across the area of the Pentland Hills, into East Lothian and Berwickshire, and then point out some of the bearings of the facts adduced upon the physical geology of Southern Scotland during the Old Red Sandstone and Carboniferous periods.

Lesmahago†.

Silurian.—The basement-rocks of the Lesmahago district consist of a series of shales and flaggy sandstones belonging to the Upper Silurian. They form an anticlinal axis in Nutberry Hill, whence they strike south-west for six miles to beyond the village of Muirkirk in Ayrshire, when they are overlapped by Carboniferous sandstones. At Nutberry Hill, notwithstanding the contorted character of the strata, this axis is sufficiently well-marked. Southwards, however, its regularity is obscured, partly by a large intrusion of felstone, partly by faulting, which possibly took place prior to the deposition of the Carboniferous rocks, and partly by the way in which these rocks overlap and conceal those of older date.

Another Silurian patch occurs in the Haughshaw Hills as the centre of another anticlinal axis. In both cases it is plain that the present exposure of Silurian strata in this region, so far removed from the great Silurian tract to the south, arises from the flexured character of the country, and the subsequent denudation of the ridges. It is interesting to observe that the axis of these flexures

* Quart. Journ. Geol. Soc. vol. xii. p. 17.

† The numerous notes which I made of the details of the geology of Lesmahago may possibly form the subject of another paper. I need not refer here to previous writers on the Lanarkshire and Ayrshire rocks, as my present subject is a special one, which their labours have not anticipated. I may remark, however, that the general geology of the district is already sketched in Sir Roderick Murchison's succinct memoir on Lesmahago Parish, Quart. Journ. Geol. Soc. vol. xii. p. 15.

is from N.E. to S.W., that is, parallel to the general strike of the country. That other Silurian anticlines will be found in other parts of this district, seems in the highest degree probable; and hence we may anticipate fresh harvests of organic remains from the prolongation of the Pterygotus-bearing shales of the Logan Water.

Lower Old Red Sandstone.—The Silurian strata, as was clearly pointed out by Sir R. I. Murchison*, graduate upwards into a perfectly conformable series of red shales, sandstones, and conglomerate-bands, which pass by alternations into a higher and very thick group of purplish-grey sandstones, often pebbly and conglomeratic. The whole series above the highest of the Silurian shales must be many thousand feet thick. That it represents the lower, and perhaps part of the middle Old Red, seems to be indicated with sufficient clearness by the geological horizon and the petrological aspect of the strata. Through the kindness of — Brown, Esq., of Lanfine, I am in possession of confirmatory evidence. He informs me that in the sandstone-quarry of Lanfine, near Newmills, Ayrshire, several specimens of *Cephalaspis* have been found, some of which are in his cabinet. A drawing of one of these was sent me; it is a well-preserved buckler of *Cephalaspis Lyellii.* The Newmills sandstones form a part of the great series which stretches eastward by Lesmahago and the Clyde, towards the confines of Peeblesshire; and there can be no doubt, therefore, that the whole belongs to the Lower Old Red Sandstone.

The Lower Old Red strata, as developed in the neighbourhood of Lesmahago, present many points of interest, into which, however, I do not enter at present. There is but one feature to which it is necessary to advert, viz. that both Silurians and Old Red Sandstones are everywhere traversed by dykes of porphyritic felstone, often of considerable size. These dykes, so far as I have been able to observe, never intersect the Carboniferous series. I have seen only a single instance (that of the Nethan section, near Kerse) where the Carboniferous strata are in contact with a felstone-dyke; and there the former, in place of showing any trace of metamorphism, present an unaltered felspathic paste, in which are imbedded fragments of the subjacent dyke. All the felspathic dykes, therefore, appear to be older than the Carboniferous, and later than the Old Red rocks of the district.

Another series of dykes deserves incidental notice here. They consist of greenstone, and are found traversing all the other rocks of the district, igneous and sedimentary, as well as several large faults, without undergoing any deflection. They preserve their course in parallel lines from S.E. to N.W., across mountain and valley, at nearly right angles to the general strike of the country. Of course they are the latest rocks of the neighbourhood.

The town of Lesmahago stands on a narrow isthmus of Lower Old Red Sandstone, which expands westward into the bare heathy uplands of Ayrshire, while to the east it swells out into the fertile

* *Loc. cit.*

undulating region in which lies the valley of the Clyde. The narrowness of the band at Lesmahago arises from the southward prolongation of the great Lanarkshire coal-field, and from the northward extension of the smaller coal-field of Douglas. That these two coal-fields were at one time connected down the valley of the Nethan, and that thus a continuous band of Carboniferous strata stretched away north from Douglas to beyond Glasgow, can hardly, I think, be doubted; and this circumstance becomes of the highest importance in any endeavour to ascertain the true relation of the Carboniferous to the Lower Old Red Sandstone throughout the south of Scotland.

In the Birkenhead Burn, the Logan Water, the Blaeberry Burn, and the Greenock Water, there is a clear passage of the green Silurian shales into the red shales, sandstones, and conglomerate-bands of the Old Red series. That series dips regularly away from the Silurian axis of Nutberry and Priesthill on the north and north-west sides. On the east side, however, as already remarked, the succession is not quite so clear, owing to a fault which throws down the red sandstones against a low part of the Silurian series. This fault seems to increase in the amount of throw as it passes to the south-west. It appears to be overlapped by another tongue of Carboniferous rocks forming the north-eastern prolongation of the Muirkirk coal-field*. Starting, however, from the section on the Logan Water, where the whole succession is very clear, and passing north-eastward by Lesmahago to the Clyde, we find the purplish-grey sandstones which form the whole of that tract dipping almost uniformly E. by N. at from 25° to 45°. There is thus an ascending series for eight miles, the total thickness of which must be at least 12,000 feet, and is probably more. Again, along the north flank of the Haughshaw Hills, which consist of the same sandstones, the dip is still easterly. Their south flank is obscured by another fault, which has tilted on end both the Old Red and the Carboniferous beds. In the middle of the hills the Silurian shales come up in an anticlinal bend as at Nutberry Hill, and are well shown along the sides of the reservoir at Parishholm, and also in the lower part of the Parishholm Burn. The axis which they form seems to run on the east side of that streamlet, and nearly parallel to it. But the Old Red and Silurian strata in this part of the district are much disturbed. As we ascend the stream, the sandstones and shales near the base of the Old Red become twisted, vertical, and broken, and this character continues until the whole passes under a thick unconformable series of white Carboniferous sandstones forming the crest of the Cairn Table ridge, and dipping W. by N. at 13°–20°.

Viewed as a whole, therefore, we have in the Lesmahago district two N.E. and S.W. Silurian axes, each with an encircling zone of Lower Old Red Sandstone. Their south-western prolongation is hidden by Carboniferous strata; while towards the north-east they

* Without a re-examination of this part of the district, I am unable to say decidedly whether the Carboniferous rocks here overlap the older strata, or are faulted against them. At present I incline to the former opinion.

gradually disappear, and the Old Red Sandstone then begins to form an ascending series towards the Clyde, the prevailing dip being E. by N.

Carboniferous.—I have referred to the tongue of Carboniferous strata which diverges from the great Lanarkshire coal-field, and extends up the valley of the Nethan to within a mile of Lesmahago. The Douglas coal-field stretches north to nearly the same distance from the town, and then bends south-westward between the channel of the Nethan and the base of the Haughshaw Hills. It becomes greatly attenuated in the Upper Monkshead Valley, and appears indeed to thin off entirely for a short distance. But a fault, which crosses the glen opposite the farm-house, throws the limestones and coals in again along the west flank of Hareshaw Hill, where the black-band ironstone was once extensively mined. From this point the Carboniferous rocks expand into the Valley of the Ayre, and up to the summit of the hills by which that valley is bounded on the south. Here and in the Douglas coal-field, although the surface often shows little else than a wide expanse of barren moorland, it nevertheless conceals mineral deposits of great value; and hence districts which a few years ago could boast only a few widely scattered hamlets, are now becoming dotted with chimneys and traversed by railroads.

A careful working-out of the details of the Carboniferous system as developed in the Lesmahago district would doubtless amply reward the labour. Especially full of interest are the alternations of marine and terrestrial strata, the disappearance of certain beds over particular areas, and the thickening and thinning of coals and limestones, as well as shales and sandstones in particular directions. Some of these appearances obtain, I believe, their true explanation in the unconformable relation of the Carboniferous to the underlying Red Sandstones to which I shall immediately advert. My observations among the Carboniferous strata were almost wholly confined to the lower limestones and the beds below them—in short, to the base of the Carboniferous series where it rests on the Old Red. The features of the junction-line I shall now proceed to describe.

In no part of the district can the junction of the Carboniferous and Lower Old Red Sandstone be more clearly made out, than along the southern margin of the Auchenheath coal-field, about a mile north of Lesmahago. By descending the streamlet called Kerse Gill, which skirts the south side of some lime-quarries and falls into the Nethan below Kerse House, we obtain a good section of both formations. Near the bridge south of Kapeshall, Old Red Sandstones are seen dipping 45° E. of N. at 25°–30°. The same series can be traced down the channel of the stream for fully half a mile, the general dip being E. by N. At the bridge above the lime-quarries, the sandstones are mottled, purple, and white, flaggy and micaceous, traversed by two small felstone-dykes. Below this bridge, the sandstones continue with the same dip, but are much whiter—so white, indeed, that at first, I doubted whether they were not Carboniferous. It was not long, however, before I satisfied myself that they really

belonged to the Old Red series. Below these pale sandstones, no rock is visible in the streamlet for some way, until at last we come to Carboniferous sandstones, shales, and limestones, full of fossils, dipping northerly at 5°–10°. These occupy the bed of the Burn for a short distance, when the dip changes to W., and they then sweep round the west side of the Nethan Valley, as far down as the foot-bridge, where they cross the river and ascend the valley on the east side. Their boundary-line then turns sharply round to the north, skirting the side of Black Hill, and curving round the north end of that hill, down into the vale of the Clyde near Crossford. By comparing the line now described and its attendant dips with the strike of the Old Red Sandstones, it will at once be seen that the one is as nearly as may be at right angles to the other. The Red Sandstones dip steadily eastward at considerable angles, while the Carboniferous undulate gently to the north and north-west. It cannot for a moment be held that any fault intervenes between the two formations; for the sinuosity of the junction-line and the undisturbed position of the Carboniferous beds forbid such an explanation.

There is only one locality in this part of the district where the actual base of the Carboniferous series is seen. It is in the channel of the Nethan, below the foot-bridge already referred to, where a set of Carboniferous sandstones, with large stems of *Lepidodendron* and *Sigillaria*, graduates downwards into a conglomerate, resting on a porphyritic felstone in the Old Red series. These dykes of felstone, as I have already remarked, never cut through Carboniferous strata. It is presumable, therefore, that they are older than these. But in the present instance, not only does the igneous rock not penetrate the Carboniferous conglomerate, but the conglomerate is really to a considerable extent formed out of the felstone, since its paste in the lower part is highly felspathic, and contains moreover distinct fragments of the peculiar rock on which it rests. The larger number of fragments composing the conglomerate consist of the whitish sandstone which I have described as occurring at the Kerse Gill. Hence, though we cannot see here the Carboniferous series actually resting on Old Red Sandstones, we yet find it formed partly out of the latter and partly out of igneous rock, which was intruded into the older series before the deposition of the Carboniferous group.

The evidence from the flanks of Black Hill is very satisfactory. That hill consists of an enormous protrusion of porphyritic felstone, having a general bedded form on the great scale, and dipping to the east along with the Old Red Sandstones among which it has been intruded. It is underlaid by hard purplish-grey sandstones, which can be seen at different points towards the south end, dipping E. by N. at from 20° to 30°. On the east side of the hill similar sandstones supervene; they are admirably shown in the channel of the Clyde, where the dip is still easterly, at from 30° to 45°. It is on the truncated ends of these sandstones that the sandstones, shales, and limestones of the Carboniferous series have been deposited.

Nothing can be clearer than the general relation of the rocks along the west flank of Black Hill. The coals there have been

worked up to the felstone; and the underlying limestones do not for some distance come to the surface. In short, we cannot but perceive that when the Carboniferous series was being formed, the west side of what is now Black Hill existed as a precipitous cliff-line, along the base of which the deposits accumulated, and that consequently the Lower Old Red Sandstones must have been tilted up and subjected to an extensive denudation before the beginning of the Carboniferous series in this neighbourhood. The section, fig. 1, Pl. XVIII., represents the visible relation of the rocks in this part of the district.

The unconformity which I wish to establish is so clearly indicated in the Kerse section, that this section might be held as decisive for the entire district. But it may be well to cite another instance, which occurs at a distance of twelve or thirteen miles S.W. from Kerse in the parish of Muirkirk in Ayrshire.

The Silurian shales which occupy the higher part of the Nethan and Pockmair Burn cross over the ridge of hills that divides the two counties of Lanark and Ayr, and stretch for five or six miles to the south-west. In the neighbourhood of Priesthill the beds are inclined at a gentle angle to the north-west. As they strike south-west, however, the angle becomes greatly higher, and (at least in the bed of the Greenock Water, below Mansfield) the beds become quite vertical. This high inclination continues for rather more than a mile, until, a little below the farm-house of Burnfoot, the vertical Silurians and a large felstone-dyke which traverses them are overlapped by Carboniferous sandstones dipping a little S. of W., at 8°. The unconformity here is of the most violent kind; for it consists of a vertical series overlaid by a nearly horizontal one. These Silurians form a part of the Nethan series, since as we trace them northward along the Greenock Water the dip lessens, and they are eventually succeeded by the red shales of the lower Old Red group. The general relations of the rocks in the upper part of the Ayr Valley are shown in the section (fig. 2).

The Cairn Table ridge, part of which is crossed by this line of section, shows the same superposition of gently inclined Carboniferous sandstones upon a disturbed and vertical Silurian and Lower Old Red series.

Again, the boundary-line of the Douglas coal-field corresponds in its general features to that of the Auchenheath coal-basin north of Lesmahago. The general dip of the Carboniferous rocks there is away from the Old Red Sandstones, which, skirting the basin, are usually inclined to the east. A fault running along the Nethan Valley from the Trows to Cummerhead has greatly disturbed the Carboniferous limestones along its course; but the connexion of the different rocks, after other parts of the district have been visited, is nevertheless quite apparent. If we could restore the strata here to their normal position, we should find the same unconformity as in other parts of the district; for no sooner does the fault die away to the north-east than the unconformity becomes at once apparent. At Boghill and Porcheek, for instance, the Old Red sandstones are seen dipping easterly at 25°; while immediately to the south the Carboni-

ferous limestone is quarried at Auchtool dipping S. by E., that is, almost at right angles to, and along the denuded edges of, the Old Red Sandstone bank to the north.

Sufficient evidence has probably now been adduced to prove that, in Lanarkshire and Ayrshire, strata belonging to the Carboniferous Limestone series rest unconformably upon certain sandstones and shales of Lower Old Red and Silurian age. Some of the features of this unconformity must be briefly noticed.

One of the first facts which struck me when I began the examination of this district was the entire absence of the vast mass of strata below the Carboniferous Limestone, known in the Lothians as the Lower Carboniferous group and the Upper Old Red Sandstone. I had traced these strata from Mid-Lothian down into Lanarkshire, not more than 15 miles distant from the district under review, and I therefore looked to meet with them below the Carboniferous Limestone of Lesmahago; but they do not exist there.

Another feature which soon presented itself was the fact that, taking as a line of measurement a certain bed of marine limestone the outcrop of which is tolerably well known, the thickness of beds between the limestone and the underlying red sandstones varied considerably throughout the district. Thus at Auchtygemel, the section on the Nethan shows a depth of Carboniferous strata below the limestone of perhaps less than 100 feet; while along the margin of the Auchenheath basin generally, the thickness appears to be always below 200 feet. At the bend of the Nethan below Gateside, these strata are (I quote from memory) somewhere about 50 or 60 feet. At Hallhill, on the west side of Black Hill, the limestone comes to rest directly on the Old Red and its associated porphyry; and the same seems to be the case at Auchmeden. From this latter locality, however, as we trace the limestones to the south-east, there gradually intervenes between it and the Old Red an increasing thickness of white and reddish sandstones. These are well exposed in a series of quarries on the top of a wooded eminence called Stone Hill, in Carmichael Parish. From where the Old Red series is covered by the Carboniferous sandstones south of Drumaben, to where the limestone crops to the west of Stone Hill, is rather more than a mile; the angle of dip at the quarries varies from 20° to 25°, while at Drumaben it is only 8°: but taking it at an average of 15°, the thickness of strata between the limestone and the Devonians will probably be more than 1000 feet. I had not an opportunity of ascertaining how far these beds extend southwards.

The other side of the Douglas coal-field, skirting the south-east flank of the Haughshaw Hills, is bounded by a marked N.E. and S.W. fault, whereby both the Carboniferous and Old Red series are tilted on end. Though I did not ascend the Carmacoup and Kinnick Waters, I had little doubt that this fault was thinning away to S.W., and that the same series of sandstones which occurs at Stone Hill would be found at the head of these streams stretching westward into Ayrshire. When on the top of Cairn Table, it seemed to me highly probable, from the contour of the hills, that the grey Carboniferous

sandstones which cap the Cairn Table ridge also occur along the hill-tops to the eastward, and hence they would range by Kinnickfoot into the Douglas coal-field.

It appears, therefore, that the Old Red Sandstone and Silurian hills to the south are flanked by a thick series of Lower Carboniferous sandstones, but that a short way northward, as we advance in the direction of the great coal-fields, this series thins rapidly away to about 50 or 60 feet in some places. Even at their greatest thickness, however, these sandstones but poorly represent the enormous depth of Lower Carboniferous and Upper Old Red sandstones in the Lothians and Berwickshire.

The lithological aspect of the base of the Carboniferous group in the Lesmahago district varies considerably in different localities. Along the southern line, where the thick Lower Sandstone series occurs, the basement-beds are reddish and conglomeratic. In the Monkshead Glen they are very red, marly, and sandy, with fronds of a *Sphenopteris*. At Glenbuck they consist of hard, reddish-grey, false-bedded sandstones. Below Kerse on the Nethan, the lowest bed I have already described as a conglomerate formed partly out of pale Old Red Sandstone, and partly out of a whitish porphyry-dyke on which the conglomerate at the point of section rests. In short, towards their base the Carboniferous rocks assimilate in general aspect to the Old Red Sandstones below. This resemblance is sufficiently close to lead one at a first glance into the belief that there is a gradual passage of the one series into the other. But the peculiar purplish-grey or chocolate colour and the fissile flaggy structure of the Old Red sandstones never, so far as I have seen, shade into the brick-red hue and false-bedded character of the Carboniferous rocks.

Finally, from what has been stated above, and from the accompanying Map, it will be seen that the base of the Carboniferous series rests successively upon many different horizons, alike of the Silurians and the Lower Old Red Sandstones. Such a transgressive line shows very clearly the unconformable relation of the Carboniferous beds to the older strata on which they lie.

Pentland and Lammermuir Hills.—Having ascertained that between the Carboniferous Limestone series and the Lower Old Red Sandstone there existed in Lanarkshire and Ayrshire a decided unconformity, I knew from previous examination that the same physical break must occur between the Upper and the Lower Old Red Sandstones. With the experience of the Lesmahago sections, I again visited the Pentland Hills, in company with Professor Ramsay, and found that the localities mutually explained each other.

In the memoir to accompany sheet No. 32 of the Geological Survey of Scotland, I have described in detail the structure of the Pentland Hills. It is only needful to mention here that the richly fossiliferous shales of the Upper Ludlow rock of that locality are overlaid by conformable red shales, sandstones, and conglomerate-bands which, there seems no reason to doubt, correspond to the similar series of

beds which at Lesmahago form the base of the Lower Old Sandstone. These Silurian and Old Red shales are covered unconformably by a thick group of sandstones and conglomerates forming the Upper Old Red Sandstone, and the Lower Carboniferous or "Calciferous Sandstone*" series of the Lothians. (Fig. 3.) Here, then, we find part of the great series of strata which is wanting at Lesmahago. We see too that, just as at Lesmahago, there is a strict stratigraphical succession through the Upper Silurian and the Lower Old Red Sandstone of that district; so at the Pentlands there is an equally perfect sequence through the Carboniferous and Upper Old Red Sandstone. The line of physical break occurs, therefore, in the Old Red Sandstone. The upper part of that formation graduates upward into the Carboniferous series; the middle and lower portions pass down into the upper Silurian; and between these two graduating series there is in the Pentland Hills, as in Ireland, a well-marked and even violent unconformity.

As the southern districts of Scotland become more thoroughly explored, more especially to the south-west, the area of Lower Old Red Sandstone and Upper Silurian strata will probably be greatly enlarged; and I have little doubt that the same unconformable relation will everywhere be found to characterize the junction of the Carboniferous and Upper Old Red Sandstones with the older rocks.

There is, however, one other area of Upper Old Red Sandstone south of the Forth to which I would advert,—that of East-Lothian and Berwickshire. The flanks of the Lammermuirs are encircled by a more or less continuous zone of red sandstone and conglomerate, resting unconformably on inclined Lower Silurian shales and grits. These strata pass insensibly upwards into the Carboniferous series; as, for instance, along the coast at Cockburnspath, and in the neighbourhood of Dunse. Below the passage-beds, the thickness of this Old Red series is sometimes very considerable. Thus, along the eastern end of the hills, the great conglomerate south of Dunbar must be at least 1500 or 2000 feet thick; and, though the greater part of this conglomerate is representative of the sandstones and marls of other parts, there is still a considerable depth of sandstones between its top and the passage-beds into the Carboniferous series.

In the red sandstones of this district, fossils have been found in several localities.

The late Dr. Fleming informed me that he had found scales of *Holoptychius* in the red sandstones of Siccar Point, that is, not far from the base of the Carboniferous series. Similar scales and teeth were found many years ago by Mr. Stevenson in the equivalent sandstones in the neighbourhood of Dunse†. I have myself found them in considerable abundance along with much-mutilated remains of plants; and Mr. Stevenson informs me that a very perfect specimen of *Cyclopteris* was found in the same neighbourhood some years ago.

* *Calciferous Sandstones*, the name given by Mr. M^c^Laren to the great sandstone series below the Carboniferous Limestone of the Lothians.

† It seems very certain, however, that these remains are not those of *Holoptychius*. They strongly resemble some which have been assigned to *Asterolepis*.

There can be little doubt, therefore, that the red sandstones, marls, and conglomerates of the south-east of Scotland are the representatives of the "Dura Den Yellow Sandstones," and the "Upper Old Red" of Ireland. They differ very widely in aspect from the Lower Old Red sandstones of Lesmahago; and if these sandstones were present in Lammermuir, they would be found to be covered as unconformably by the Old Red conglomerates and sandstones of East Lothian and Berwickshire, as, a few miles to the west, they are by the Old Red and Carboniferous conglomerates and sandstones of the Pentland Hills.

In short, throughout the whole of central Scotland the Upper or Holoptychius-beds of the Old Red Sandstone are found to graduate by almost imperceptible stages into the Lower Carboniferous series. The two formations form one great lithological whole; and we can in general define their mutual limits on the map only by an arbitrary shaded line. But they are both strongly marked off from the great series of chocolate-coloured sandstones of Lanark and Ayrshire, alike in mineralogical, stratigraphical, and palæontological aspect. That series graduates downward into the Upper Silurian, with which it forms one continuous whole; and between these two formations and the two former, occurs the great physical break above described. In fine, the Upper Silurian and the Lower Old Red Sandstone of south Scotland form physically one connected group, the Upper Old Red and Carboniferous form another, and the two groups are everywhere separated by a marked unconformity.

Physical Geography of South Scotland during the Old Red Sandstone and Carboniferous periods.—The facts presented in this paper seem to afford some indication of the contour of the southern part of Scotland during the accumulation of the Old Red Sandstone and Carboniferous series.

At the commencement of the Upper Old Red period, the Silurian and Lower Old Red Sandstone had been considerably altered from their original horizontal position. In the district of the Pentland Hills the disturbance amounted even to verticality, while in Lanark and Ayrshire it consisted of a series of gentle anticlinal folds, which, however, seem to have been materially increased in inclination during subsequent periods. Probably more or less in connexion with this disturbance are the numerous and often extensive protrusions of felspathic rocks which intersect the tilted strata. Much additional light requires to be thrown on these changes, as well as on others which may have taken place during the interval represented by the unconformity above described. At present we know little more than that the disturbing movements had ceased before the commencement of the Upper Old Red Sandstone.

It was on the uneven surface left by these movements, that the Old Red conglomerate and sandstones of the Lothians and Berwickshire began to be thrown down. I think there is good evidence to prove that, when this period began, the great Silurian region of South

Scotland stretched away from south-west to north-east as a long island, indented by narrow inlets and curving bays. Some parts of the coast-line were low and sandy; but a large portion seems to have resembled the existing coast at St. Abb's Head, and to have risen as a perpendicular cliff-line worn into clefts and stacks, and deep ocean caves. The sea probably ran in broad sounds between this island and the Cumbrian mountains on the one side, and the southern flank of the great Grampian chain on the other.

From the commencement of the Upper Old Red and onwards through the Carboniferous, the land underwent a process of subsidence, which, though in its later stages often retarded and even reversed, yet continued the dominant movement in this part of the country.

As it went on, the long Silurian and Lower Old Red island became narrowed in outline, the bays on either side advanced nearer to each other, until by degrees they met, and the main island merged into an archipelago. The stages of the subsidence, in so far as they can be made out in the region of Lammermuir, will shortly be described in the Memoirs of the Geological Survey. What I more especially wish to point out at present is, that from the facts presented in this paper we were led to notice that the west part of the island continued above water long after the eastern part had become submerged. That area which now forms the southern portion of Lanarkshire and Ayrshire, perhaps along with much of the adjacent district, continued to be land when the site of the Lothians and Berwickshire had sunk below the sea and become covered over with many thousand feet of sedimentary matter. It was not until the whole of the Upper Old Red Sandstone, and nearly the whole of the Lower Carboniferous group had been deposited, that the bases of the Lesmahago Hills were washed for the first time by the waves of the encroaching sea. Either, therefore, the south-western district of Scotland must have stood several thousand feet higher than the south-eastern, or the rate of submergence must have been greatly more rapid over the latter area than over the former.

It would be premature, without many more additional details, to decide which of the two suppositions is the true one, although a difference in the rate of submergence seems at present best to explain the facts. There are also other points connected with the ancient physical geography of southern Scotland on which I much wish to touch; but I must delay their consideration until I am able to lay before the Society the results of another visit to the uplands of Peebles and Lanark.

February 1, 1860.

Thomas Pease, Esq., Westbury, Gloucestershire, was elected a Fellow.

The following communications were read:—

1. *On some* Fossils *from the* Grey Chalk *near* Guildford. By R. Godwin-Austen, Esq., F.R.S. F.G.S.

[This paper was withdrawn by permission of the Council.]

(Abstract.)

In the cast of the body-chamber of a large *Nautilus elegans*, from the Grey Chalk of the Surrey Hills, near Guildford, the author found (the specimen having been broken up by frost) some lumps of iron-pyrites, and numerous specimens of *Aporrhais Parkinsoni*, with fragments of *Turrilites tuberculatus*, *Ammonites Coupei*, *A. varians*, and *Inoceramus concentricus*. These species are either rare in the Grey Chalk or not known to the author as occurring in this bed; and he believes that the specimens referred to were accumulated in the shell of the Nautilus (possibly by the animal having taken them as a meal shortly before death) at a different zone of sea-depth to that in which the Nautilus and its contents sank and became fossilized. Mr. Godwin-Austen referred to these specimens as being indicative of the contemporary formation of different deposits with their peculiar fossils, at different sea-zones; of the transport of the inhabitants of one zone to the deposits of another; and as a possible explanation of the abundance of small angular fragments of Mollusks, Echinoderms and Crustaceans in the midst of the very finest Cretaceous sediment.

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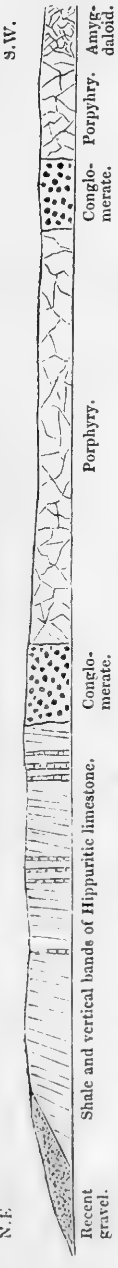
2. *On some* Cretaceous Rocks *in the* South-Eastern Portion *of* Jamaica. By L. Barrett, Esq., F.G.S., Director of the West Indian Geological Survey.

Below the thick Tertiary deposits in Jamaica are found thin beds of fossiliferous limestone, underlaid by igneous rocks. These strata form the subject of the following communication.

The newest bed of the fossiliferous limestones is exposed on the north side of the Plantain-garden River, three miles west of Bath. This section shows a bed of compact limestone, 8 feet thick, resting on a thick bed of conglomerate, and overlaid by shale.

The shale is of a dark colour and without organic remains. The limestone is compact and grey, with thin veins of calc-spar; it contains numerous fossils, all of them characteristic of Cretaceous or other Secondary strata, viz. *Inoceramus*, *Hippurites*, and *Nerinæa*.

The conglomerate is composed of rounded pebbles of igneous rocks and a white fossiliferous limestone; it is succeeded by a great thickness of unfossiliferous black shale.



Section on the Plantain-garden River, Jamaica.

A quarter of a mile higher up the river there is a section of some vertical beds of limestone, probably older than the series already described. A bed of conglomerate separates them from great masses of porphyry. This section (see woodcut) exhibits thin bands of limestone, alternating with shale, containing limestone-nodules. Some of the thin bands of limestone are crowded with fossils, principally *Inoceramus*, *Hippurites*, and a species of *Bulla* (?).

These fossiliferous beds are succeeded by a bed of conglomerate, 12 yards thick, composed entirely of pebbles of porphyry, identical in structure and colour with the adjacent mass. The conglomerate is not altered at its junction with the igneous rock. The porphyry in contact with the conglomerate is of a purple colour, and contains small crystals of felspar; in some places it is made up of large felspar-crystals imbedded in a dark cellular base (the cavities being sometimes filled with kernels of carbonate of lime); and at the distance of an eighth of a mile it passes into an amygdaloid. The porphyries are divided by a bed of conglomerate 36 yards wide.

A thick bed of grey limestone crosses the medial ridge of mountains, at an elevation of 2500 feet above the sea; and at a distance of twelve miles from the east coast its strike is N.W.—S.E., and its general dip N.E.; it rests on numerous alternations of igneous rock, shale, and conglomerate. The following is the descending order at Cold Ridge:—

Grey limestone containing *Hippurites*, and with black flints enclosing *Ventriculites*, &c., resting on a ragged surface of porphyry (the cavities in the upper surface of the porphyry sometimes filled with fossil shells). The porphyry is succeeded by a thin bed of shale; the shale by thick beds of hornblende-rock, divided by a bed of conglomerate entirely composed of rolled fragments of the same igneous rock.

The porphyries and hornblende-rocks of these localities are evidently interbedded, as they have not altered the stratified rocks in contact with them, and are divided by beds of shale and conglomerate (the conglomerate being composed of fragments of the lower volcanic rock).

There can be no doubt that the fossiliferous limestones are of Cretaceous age,—the family *Rudistes* being characteristic of the Cretaceous rocks both of Europe and America, and *Inoceramus* and *Nerinæa* being peculiar to Mesozoic strata.

Sir H. De-la-Beche, in his memoir on the Geology

of the East of Jamaica *, referred these rocks to the palæozoic series ("Transition"); but he was guided entirely by mineral characters, not having found any organic remains.

It is also evident that the igneous rocks forming the base of this series, and interstratified with some of the shales and conglomerates, were erupted prior to the deposition of the Cretaceous limestones, and at intervals of time sufficient for the formation of the interbedded aqueous strata.

The second and third of the above-described sections much resemble those of the Penquenes ridge of the Andes (described by Darwin†), where porphyries, which had flowed as submarine lavas, alternate with conglomerates, composed of the same rocks, and overlaid with beds containing Cretaceous fossils.

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3. *On the Occurrence of a Mass of* Coal *in the* Chalk *of* Kent. By R. Godwin-Austen, Esq., F.R.S., F.G.S.

The first notice which appeared in the public papers relative to the coal found in the Chalk of Kent was the following:—

"*Coal discovered in Kent.*—While the workmen employed on the London, Chatham, and Dover Railway were engaged in tunnelling between Lydden-hill and Shepherdswell, a few miles from Dover, they came upon a fine seam of coal, and, what is most remarkable, the coal is on all sides surrounded with chalk, with the usual seams of flint as are seen on the cliffs of Dover. The more the seam is entered upon the better becomes the quality of the coal. Altogether it is an interesting study for geologists, and may probably in a short time become of vast importance to commerce and the community."—*Dover Chronicle.*

To this succeeded an account of the visit of Messrs. Malden and Andrews (of the East Kent Natural History Society):—

"*The Discovery of Coal in Kent.*—In accordance with the arrangement made at the last meeting of the East Kent Natural History Society, the Rev. B. S. Malden and Mr. A. B. Andrews visited Lydden on Monday, for the purpose of ascertaining the facts with reference to the alleged discovery of coal. It appears that the substance found is in reality coal, though its occurrence in the position in which it lay is difficult to explain. The workmen engaged in executing Lydden tunnel found imbedded in the chalk, at a depth of 180 feet, a mass of coal weighing about 4 cwt. With the exception of this lump no other coal has been seen. In their walk through the tunnel the visitors saw great numbers of flints in the chalk, and also veins of clay and apparent faults in the formation, but where the coal was found there was nothing of the kind. The chalk here was solid, without fault or fissure. The coal is bituminous, containing veins of ferruginous clay. Mr. Malden having applied a lens, it took

* Trans. Geol. Soc. 2nd ser. vol. ii. part 2. p. 143.
† Darwin's 'Naturalist's Voyage,' p. 319.

fire in a short time. The visitors brought away a specimen, weighing about 31 lbs., which Mr. Walker, the sub-contractor, courteously caused to be sawn off, and which the East Kent Natural History Society will present to the Canterbury Museum. The discovery of coal under the circumstances described is, we believe, extremely unusual."—*Kentish Gazette*, Oct. 6th, 1859.

It was not until after this that I put myself into communication with Mr. Mills, the engineer in charge of the construction of the line in question. Writing to me on the 3rd of November, he says,—"There is no sign of coal in the tunnel now; we found one lump only, about 4 cwt."

In December I received from the same gentleman a portion of the coal so met with. He observes,—"On it you will perceive some of the chalk-bed in which it was lying. Its immediate bed was chalk strongly tinged with an iron-rusty colour. There was only one mass of coal, from about 4 to 10 inches thick and about 4 feet square."

These particulars are confirmed by inspection of the specimens here exhibited.

The points of interest which suggest themselves are mainly referable—1, to the age of the coal; 2, to its occurrence in the Chalk.

1. The mass in question is undoubtedly a vegetable product, originally formed on some terrestrial surface; and was part of a bed of Carbonaceous matter, parted by thin seams of ferruginous deposit.

It is bituminous; burns readily in the flame of the spirit-lamp, giving off a peculiar smell like that of retinasphalt. In these, as in its external characters, it resembles some of the Oolitic coal of our own area and some of that of the Wealden of the Continent. It is probably of Oolitic age; it is certainly unlike any coal of the true Coal-measures.

2. The specific gravity of this coal precludes the supposition that it could have floated away of itself into the Cretaceous sea.

Considering its friability, I do not think that the agency of a floating tree could have been engaged in its transport; but, looking at its flat angular form, it seems to me that its history may agree with what I have already suggested with reference to the boulder in the Chalk at Croydon*. We may suppose that during the Cretaceous period some bituminous beds of the preceding Oolitic period lay so as to be covered by water near the sea-margin or along some river-bank, and from which portions could be raised off by ice, and so drifted away, until the ice was no longer able to support its load.

The northern limit of the Cretaceous seas in the European region reached high enough in latitude to have given the requisite degree of winter-cold; and within the same limits there are localities where Oolitic strata formed the coast of the Cretaceous sea.

We may confidently look forward to the day when, by the aid of these extraneous masses which have been dropped over the bed of the sea of the Cretaceous period, we shall be enabled to lay down, as on our own charts now, the set of the marine currents of that sea.

* Quart. Journ. Geol. Soc. vol. xiv. p. 252.

4. *On the* PROBABLE EVENTS *which succeeded the* CLOSE *of the* CRETACEOUS PERIOD. By S. V. WOOD, Jun., Esq.

[Communicated by S. V. Wood, Esq., F.G.S.]

(Abstract.)

THE object of this paper was to show that the close of the Secondary period was followed by the formation of a continent having a great extent from east to west, and at that time chiefly occupying low latitudes; that this direction of continent prevailed throughout the Tertiary period; and that in certain portions of the southern hemisphere, particularly in Australia and New Zealand, there have been preserved portions of the Secondary continent with isolated remnants of the Secondary Mammalia and Gigantic Birds.

These conclusions were arrived at by a consideration of the direction of the principal volcanic axes in the Secondary and Tertiary periods. The Secondary continent was (the author considered) mainly influenced by volcanic axes which came into action at the close of the Carboniferous, and continued through the Secondary Period. These axes were (in the northern hemisphere) that of the Oural, that of the north of England prolonged into Portugal, and that of the Alleghanies, having all a north and south direction; and (in the southern hemisphere) those of eastern Australia and New Zealand, having a similar alignement. From this circumstance an inference was drawn that the Secondary continents had generally a trend from north to south, governed by volcanic bands having this direction; while, as the Secondary formations indicate a great extent of sea over the northern hemisphere, the bulk of the Secondary continent lay in the southern hemisphere.

The elevation of the bed of the Cretaceous sea, it was inferred, was due to volcanic forces acting from east to west; and the author adduced evidence of this action having become perceptible during the later part of the Cretaceous period. He considered that the direction of all the Post-cretaceous lines of volcanic action governed the direction of the continent during the Post-cretaceous period, and pointed out that these were nearly all in an easterly and westerly direction, coincident with the existing volcanic band which extends from the Azores to the Caspian, and thence (with an interval of intense earthquake-action between the Caspian and Bengal) extends to the Society Isles. He concluded that they gave rise to a continent extending from the Caribbean Sea to the Society Isles,—many reasons uniting to show a land-connexion between America and Europe at the dawn of the Tertiary period, the submerged continent of Oceanica also indicating the easterly extension of Southern Asia; and that, since this continent receded to the north at the dawn of the Tertiary period before the inroad of the Nummulitic Sea (which stretched from the south-east through Western Asia and Southern Europe, and was, as the author conceives, the oceanic equivalent of the Eocene basins of Europe), the greater portion of the deposits formed

in the interval between Cretaceous and Eocene times must be now under the Southern Oceans.

The author then adverted to the circumstance that the recent great wingless Birds and the nearest living affinities of all the Secondary Mammalia yet known occur only in the Southern hemisphere. From this, and from some considerations as to the Vegetation, he concluded that, while parts of the Secondary continent yet remain in that hemisphere incorporated more or less into the Post-cretaceous continent, other parts of it, such as Australia and New Zealand, have remained isolated up to the present time to an extent sufficient to preclude the migration of Mammalia and wingless Birds, the terrestrial fauna of those lands being the isolated remnant of that of the Triassic or the Oolitic period. He inferred that the wingless Birds, excepting the swift Struthionidæ, have been preserved solely by isolation from the Carnivora, which do not appear as an important family until the Pliocene age; and he instanced the *Gastornis* of the Eocene (which had affinities with the Solitaire and Notornis) as evidence that the apterous birds had survived until that period, at least when the true Carnivora had not appeared.

An inference was then drawn that the remains of the Secondary continent, accumulated to the southward, caused cold currents to flow to the southern shores of the Post-cretaceous continent, causing the extinction of the bottom-feeding and shore-following Tetrabranchiata, to which Mr. Wood attributes the destruction of the Cestracionts which fed on them, and that of the marine Saurians that fed on the Cestracionts. The preservation of the Dibranchiata, on the contrary, was attributed to their being ocean-rangers. The extinction of the Megalosaurians he attributed to the effect produced on vegetation by the alternation of dry seasons during the year, brought about by a great equatorial extent of land,—the extinction of the herbivorous Megalosaurians, by this cause, involving that of the carnivorous.

The author also alluded to the contiguity of volcanos to the seas or great waters, which he considered to admit of explanation by every volcanic elevation causing a corresponding and contiguous depression, which either brings the sea or collects the land-drainage into contiguity with the volcanic region; and in conclusion he alluded to the law of natural selection and correlation of growth lately advanced by Mr. Darwin, in the soundness of which he asserted his belief.

DONATIONS

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American Journal of Science and Arts. Second Series. No. 85. January 1860. *From Prof. B. Silliman, For. M.G.S.*

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Assurance Magazine. Vol. viii. Part 6. No. 38. January 1860.

Athenæum Journal. For January, February, and March.

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THE

QUARTERLY JOURNAL

OF

THE GEOLOGICAL SOCIETY OF LONDON.

PROCEEDINGS

OF

THE GEOLOGICAL SOCIETY.

February 15, 1860.

The following communications were read:—

1. *On the* Probably Glacial Origin *of some* Norwegian Lakes. By T. Codrington, Esq., F.G.S.

The lakes to which attention is called are those so frequently found situated at a short distance from the head of a fjord on the western coast of Norway. The fjord and the valley in which such a lake lies are parts of one mighty chasm bounded by almost perpendicular mountains, which rise often thousands of feet from the water's edge. The valley generally shows traces of the former existence of a glacier, and is now occupied by a rapid river. Instead of at once emptying itself into the fjord, this river falls into a lake, perhaps six or seven English miles long, but rarely a mile wide, and very deep. Between this lake and the fjord, there is a barrier consisting of rolled stones, shingle, and coarse sand, roughly stratified, through which an outfall has been cut to the fjord. The distances between some of these lakes and the fjord are subjoined, from which the mass of these deposits may be estimated:—

	Lakes.		
Sogne Fjord.	Sogndals Vand	$3\frac{1}{4}$	miles from Fjord.
	Haslo Vand	$3\frac{1}{4}$	,, ,, ,,
	Veitstrands Vand	$1\frac{1}{2}$	,, ,, Haslo.
	Skiolden Vand	1	,, ,, Fjord.
	Aardal Vand	$1\frac{1}{4}$	,, ,, ,,
	Urland Vand	2	,, ,, ,,

	Lakes.	
	Evanger Vand	3 miles from Fjord.
Hardanger Fjord.	Eidsfjord Vand	1½ ,, ,, ,,
	Gravens Vand..........	2 ,, ,, ,,
Nord Fjord.	Bredeims Vand	3 ,, ,, ,,
	Oldens Vand	1 ,, ,, ,,
	Lodens Vand	2 ,, ,, ,,
	Opstryns Vand*........	4½ ,, ,, ,,

The height of this barrier may be as much as 120 feet above the lake, in terraces one above the other. At the inner end of the lake a similar terraced deposit frequently occurs. This is the case at Vasenden, at the inner end of Gravens Vand, and at Sæbö at the inner end of Eidsfjord Vand, which one passes on the way from Vik to the Voring-foss. This latter lake is 1½ mile long and ½ mile wide, and, according to the peasants, 200 feet deep. The sides rise from the water to a height of 1000 feet, so abruptly that landing is impossible. They are smoothed, and striated horizontally; and these marks of glacial action continue beyond the lake-barrier for some distance on the sides of the fjord. The rolled pebbles and coarse sand, of which the barrier consists, are disposed in terraces at four distinct levels, the highest being about 100 feet; and similar terraces, to about the same height, exist at the inner end of the lake.

Stratified deposits of a similar character, disposed in terraces, are very general, and occur not only where there is no evidence of the existence of a former glacier, but where the presumption is altogether the other way. Keilhau has traced such deposits, in connexion with lines of erosion, from Lindesnœs to the North Cape, and has shown that sea-shells of existing species are constantly found in deposits the formation of which is intimately connected with that of the terraces. M. Bravais has studied in detail the terraces in Alten Fjord, and describes them as composed of débris brought down by the rivers, and deposited in what was then an arm of the sea. Terraces frequently line the sides of the wider valleys for a considerable distance from their present junction with the fjord, and in some cases appear to be the remains of a lake-deposit, much of which has been cut away by the river, which now runs perhaps 200 feet below. A moraine-like look is sometimes given by the occurrence of numerous angular blocks in the stratified sand; these, however, have come from the boundary-walls of the valley, whence fragments are detached in numbers every spring.

But, while bearing in mind these facts, must we not rather attribute the accumulations, with the deep lakes behind, to glacial action? We must then suppose that the barrier between the lake and the fjord represents a terminal moraine deposited beneath the waters of what was then a fjord, at a time when a glacier filled the valley and stretched down part of the fjord. A comparatively rapid decrease in the length

* For some of these lakes the writer cannot answer from personal knowledge; but it is believed that all, and many others not named, are of the character under notice.

of the glacier must then have taken place, to leave the space now taken up by the lake; and then another terminal moraine must have been formed beneath the water, which exists now as the terraced deposit at the inner end of the lake. Another shrinking of the glacier would leave the hollow for the second lake (where two exist in the same valley). The terrace-form must have been given as the moraine was gradually upheaved above the water-level.

The resemblance between these lake-barriers and the ordinary terraced deposits containing recent shells is so strong as to render a more detailed examination and comparison interesting. A practised observer of moraine-deposits would perhaps detect the usual characteristics; and if these notes should serve as a point of departure for any such, their end will be attained.

The river between the lake and the fjord, cutting through the very heart of the deposit, often affords good fishing-quarters; and on a "blank" day a man might with advantage turn his attention to the banks of the stream, and search for a scratched pebble or other sign of the origin of the débris around him.

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2. *On the* Drift *and* Rolled Gravel *of the* North *of* Scotland. By T. F. Jamieson, Esq.

[Communicated by Sir R. I. Murchison, F.G.S. &c.]

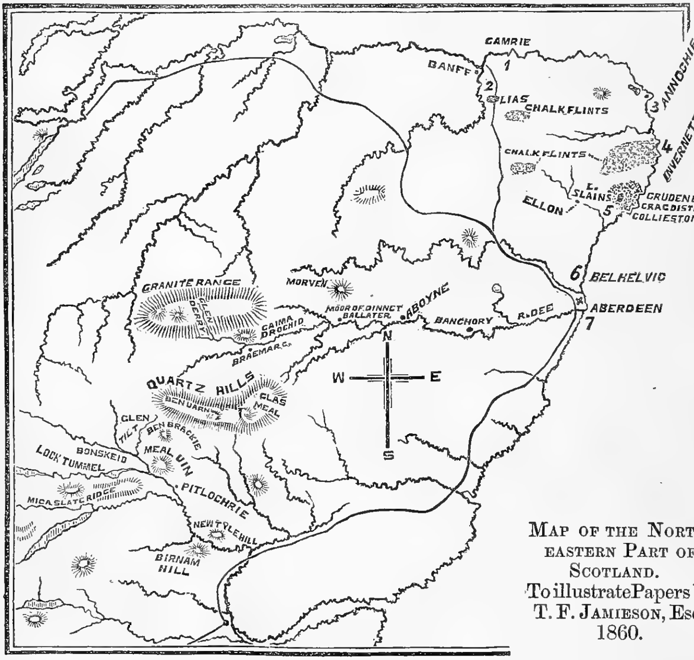
Contents.

§ 1. In a former communication* I gave an account of some features of the Pleistocene deposits along the coast of Aberdeenshire, showing that in certain localities remains of marine animals occur of a character similar to those met with in the later tertiary beds of the Clyde district, and, like them, indicating the presence of a colder sea. The following pages are devoted chiefly to the Drift of the interior of the country and of the higher grounds, more especially as regards that part of Scotland lying between the Moray Firth and the Firth of Tay.

In the lower parts of this district we find the drift-beds and brick-clays covered by a widespread accumulation of water-rolled gravel, often of great thickness and destitute of fossils. It is poured out in greatest profusion towards the mouths of valleys, and pervades all

* Quart. Journ. Geol. Soc. vol. xiv. p. 509.

Fig. 1.—*Sketch-map of Aberdeenshire and the neighbouring districts, showing the position of the Fossiliferous Drift, the Crag-beds, the Chalk-flints and Greensand, and the patch of Lias.*



Near Gamrie (1) and King Edward (2) Arctic Shells have been found in sandy strata of the Drift. At Annochie in Rattray Bay (3) Arctic Shells and Foraminifera occur in brick-clay (see Q. J. G. S. vol. xiv. p. 520). At Invernetty Bay (4) broken Arctic Shells occur in brick-clay. At Auchmacoy (5) the skull of a Seal and broken Shells have been found in brick-clay (*ibid.* p. 514). The brick-clay at Black Dog or Belhelvic (6) contains Arctic Shells. The skeleton of a Bird was found in brick-clay at Aberdeen, and Fish-bones in brick-clay at Torry near by (7).

the river-basins I have examined, decreasing in extent as we ascend their course.

It is not, however, confined to the neighbourhood of those streams, but also covers many tracts where no river appears to have existed.

All along the valley of the Dee, from the seaport of Aberdeen to Braemar, which is situated nearly sixty miles into the interior, this upper rolled gravel is everywhere to be found, diminishing, however, greatly in quantity towards the head of the valley.

At Aberdeen it forms large swelling mounds and little hills, on which a great part of the city and its suburbs is built. In many places it is spread out in wide horizontal sheets, as at Aboyne, the Moor of Dinnet, Ballater, and elsewhere. Again, it is met with tumbled up in tumultuous hillocks or longitudinal mounds parallel to the strike of the river. But, wherever we find it, it is always clearly distinguishable from the subjacent drift, 1st, by the absence of the striæ or glacial *burinage* on the pebbles; 2nd, by the highly water-rolled aspect of the deposit; and 3rdly, by its looser texture and different hue,—for the drift in this valley is all of a bluish or brownish-grey colour, while the gravel is of a ferruginous tint. The junction of the two beds is also in general sharply defined. Nowhere can it be better studied than at the Moor of Dinnet, which is situated about thirty-five miles inland, between the villages of Aboyne and Ballater, and at an altitude of, probably, 600 feet above the sea.

In some of the sections there, I noticed a feature of this gravel that would seem to indicate the action of a current flowing down the valley, and not a deposition on the beach of a lake or sea-margin; and as I have not seen this character noticed by any one, some description of it may be useful.

If the pebbly bed of a rapid-flowing river be examined, it will be found that the stones in it have a tendency to assume a certain position, which is probably that of greatest resistance to the stream. Where the stone is of an oval and flattish form (as most water-worn river pebbles usually are), this position is not horizontal, but deviates therefrom in this respect, that it dips towards the current, thus:—

Fig. 2.—*Position of an oval pebble in a stream.*

Consequently, if you place yourself on a sheet of such pebbles and look down the stream, you will observe that the stones, as a rule,

Fig. 3.—*Position of oval pebbles in a stream.*

present their sloping faces to the view (fig. 3); whereas if you reverse your position and look up the stream, you will see their ends pointing

towards you; and a section through such a bed, parallel to the line of current, will show the pebbles with a general tendency to that position. This is best exemplified when the stones are pretty large, say, from six to twelve inches in length.

Now I observed that the coarse shingle forming the Moor of Dinnet, in some of the fine sections laid open by the river, displayed this feature,—showing, as I conceive, that it had been lodged by a rapid current of water flowing down the valley.

This water-rolled gravel I have examined along the Don, the Ythan, the Deveron, the Findhorn, the Spey, the Tummel, the Tay, and various other streams, and have found it everywhere to present similar features. It seems to have been formed out of the pre-existing drift, being merely the stones and sand of that deposit, the clay and muddy matter having been washed out. The fragments, however, have been rolled about so long, that their angularities have been for the most part ground off and the whole reduced in size. This of itself would seem to involve a considerable lapse of time, and to forbid the supposition of its formation being entirely due to any sudden rush of water.

It fringes the sides of many of the larger valleys to heights sometimes 200 feet above the adjoining stream, invariably capping all the drift-deposits, but seems of older date than the submerged forests and marine beds of the raised beach that lines the coast of Scotland to a height apparently nowhere much exceeding 40 feet above the present sea-level.

It is also displayed in many places out of the way of all rivers, and is frequently accumulated in long mounds behind masses of rock that present bare and craggy faces on the opposite side. In valleys the craggy side looks up the stream; and in places where no river exists it is presented in general to the interior, the tail pointing seaward.

Although much discussion has arisen about the drift and its transported boulders, less attention has been paid to this upper gravel; and as it is not peculiar to any one district, but occurs in all the lower grounds and along all the lines of drainage of the country, it deserves more investigation than has been yet bestowed on it. That it is not the result of ordinary sea-action along the shallows of former coast-lines is probable from several considerations:—

First. From its position. It does not occur as belts or terraces along the sides of the hills, but is chiefly developed in the *middle* of depressed tracts, as if it had been projected down the valleys. Now the action of the sea, or of the waters of a lake breaking upon a shore, is to *heave up* sand and pebbles and pile them along its margin.

Second. From the arrangement of the pebbles, and the false-bedding,—indicating, as I have already mentioned, the action of a current flowing in one definite direction.

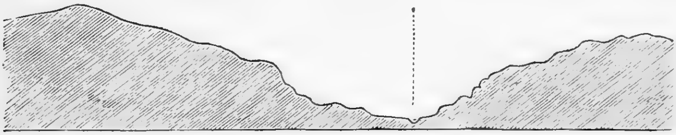
Third. From this gravel being occasionally thrown together into dome-shaped tumuli and abrupt hillocks of considerable height, such

as we do not see on any present coast-line ; and also from its uniform increase towards the mouths of valleys.

Fourth. From the absence of marine fossils.

In examining the course of many rivers in connexion with this subject, I observed that where the valley was narrowed by the approach of the enclosing hills, so as to form a gorge, pass, or ravine, the sides of such ridges were denuded of all drift to a most remarkable degree, and in a manner that seemed to me inexplicable by any mere river-action however prolonged; for this denudation frequently ascends many hundred feet, sometimes even a thousand feet and more above the present bed of the stream, and has imparted a bare, stony, washed aspect not visible on the other sides of the hills even where the slope was of equal steepness. Such appearances are

Fig. 4.—*Section across the Valley of the Tay at Birnam, showing the excavation of the Drift.* Distance $2\frac{1}{2}$ miles.



seen on the Tay at the Pass of Birnam, where the west side of the Hill of Newtyle has its rocky strata laid bare all the way up to the summit, which is about 900 feet higher than the river at that place. The denuding agent has in this case evidently flowed over the crest of the hill; for the rock at the top, which is of a coarse clay-slate, sticks out in lumpy knobs, the intermediate spaces between which have been swept clean of all small débris ; while the opposite flank of the Hill of Birnam has been bared of earthy cover to similar heights. The Hill of Craig-y-barns, at the north side of Dunkeld, is also remarkably denuded even to its summit, which is about 1150 feet high. I met with no polish nor striæ on these rocks indicating glacier-action as the cause of this remarkable denudation, although the texture of these masses seemed eminently adapted in many cases for taking and retaining such markings.

What is further interesting in this locality is a long hollow stretching from Blair Gowrie towards Dunkeld, and terminating at the Loch of the Lows near the latter town. Now I found by aneroid measurement that the summit-level of the road, where it crosses the watershed between this loch and the Tay, is about 302 feet higher than that river at Dunkeld Bridge. This watershed also presents great signs of denudation, consisting of masses of rugged gneiss scoured bare of all drift and débris ; and the face of the hill to the north has also a very bare, washed appearance.

Sir Charles Lyell, writing of this locality in 1840 (see Proceedings of Geol. Soc. vol. iii. p. 342), mentions that a continuous stream,

from three to three and a half miles wide, of boulders and pebbles is found along this hollow, from Dunkeld, by Blair Gowrie, eastward to the sea at Forfar, and that, although its course is followed by no great river, it is marked everywhere by lakes and ponds, surrounded by gravelly ridges 50 to 70 feet high. Sir Charles further remarks the absence of marine fossils, and admits the difficulty he found of accounting for the arrangement of this upper gravel of Forfarshire, proposing as the most feasible explanation, that an estuary had extended by Blair Gowrie to Dunkeld, and that these overlying ridges of sand and gravel might have been formed one after the other in the same manner as the bar of sand and shingle that now crosses the mouth of the Tay.

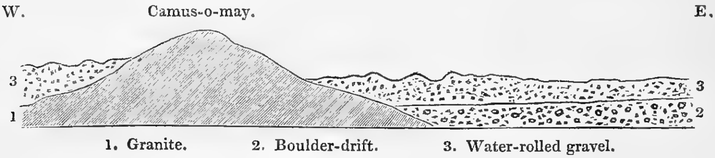
I may here remark that if an estuary had extended up in this manner, a similar one would have stretched far up the valley of the Tay, and this watershed would have formed a land-strait between these two arms of the sea: and Mr. Darwin, in explaining his theory of the origin of the parallel terraces in Lochaber, has shown that such land-straits have a tendency to be silted up, the more so in proportion to their narrowness, and on the recession of the sea would coincide with a terrace or raised beach at corresponding levels.

Now here, instead of a silting up, we find remarkable denudation; instead of belts of terraces, we have tumuli and ridges of gravel *along the midst* of the depression. Further, in the neighbourhood of the Kirk of Caputh, to the eastward of the Pass of Birnam, we see tails of detritus stretching from behind the rocky masses of Stenton, that present denuded fronts looking up the valley.

About Killiecrankie, in the narrows of the Tummel, the hill-sides are swept to a remarkable degree; and on other rivers like phenomena will occur to the recollection of most readers.

In tracing the water-rolled gravel up to such narrow passes, I have observed that its materials become coarser, and its arrangement more tumultuous and irregular as it approaches such points, until we find it in their immediate neighbourhood containing large boulders many feet in diameter. I was particularly struck with this in examining the Moor of Dinnet, before alluded to. This moor con-

Fig. 5.—*Section of the Moor of Dinnet.*



sists of a wide plain of drift covered by a sheet of this rolled gravel, which in its eastern portion is spread out in a horizontal manner, containing many seams of sand interstratified with fine pebbly shingle; but as I approached the rocks of Camus-o-May, where the valley is narrowed by a ridge of granite protruding from Culbleen that almost bars the passage, I found (as I expected from similar

observations elsewhere) the gravel tumbled into undulating ridges of extremely coarse material made up of well-rolled boulders, some of them 4 to 7 feet in length, mixed with large pebbles and shingle, until at the rocky barrier it thinned quite out, nought being left but a few large blocks that seemed to have been too heavy to move further. Likewise the boulder-drift forming the substratum of the moor seems to get thinner as you approach the rocky barrier, as if it had suffered more denudation thereabouts than further east. No difference, however, occurs in *its* texture; all is of the same quality from one end of the moor to the other.

Now these features of the gravel seemed to me to indicate that the water which lodged it must have been in much more violent motion in the neighbourhood of this contracted part of the valley than in the open expanse of moor to the eastward; and the whole features of the locality, the well-washed flank of Culbleen, and that of the opposite Hill of Pannanich seemed to tell of a large body of water passing eastward down the valley, sweeping the narrow gorges bare, and projecting the gravelly débris out into the open spaces below.

In looking for such an agency, we find several to choose from, such as—

1. The bursting of lakes higher up the valleys. These may have been temporary accumulations of water dammed up by glaciers or landslips.
2. The action of rivers during floods, which may have been caused either by great rains or the melting of extensive masses of snow and ice.
3. The retreating action of the sea during the emergence of the land from the waters of the marine drift.

I have already said that the well-rounded aspect of the pebbles, indicating long-continued rolling by water, forbids the supposition of one catastrophe doing the whole by the sweep of a sudden wave or deluge passing over the country. And further, as this gravel is found not along a few rivers, but along all that I have hitherto examined, without exception, and likewise along minor streams, I think the first of the suppositions enumerated above becomes highly improbable: for it can scarcely be thought that there has been a bursting of lakes in all the water-courses; and, indeed, with the exception of accumulations of water dammed up by glaciers and the like, such bursting or suddenly giving way of a natural lake is an event of the greatest rarity—indeed, I do not at present remember having read of an instance of it.

In seeking for a cause, therefore, we must have one of general application.

Now the long-continued action of the rivers themselves, during and after the emergence of the land, is just such a universally present agent as we are in search of. And the arrangement of the gravel is, as I have shown, very like what might be expected from a seaward-flowing current cutting through the previously deposited drift; while the absence of all marine fossils tends further to enhance

the probability of a fresh-water origin. The highly water-rolled complexion of the pebbles, again, is also in favour of this view. And then, as to the immense profusion of this gravel being apparently beyond the power of such streams as now occupy the valleys, this is a difficulty that vanishes greatly on consideration; for it is a mere question of time. A stream flowing through stony drift will in a given time produce a certain amount of gravel; give it long enough, and what will it not accomplish? During the long array of centuries, when the bed of the Pleistocene sea was heaving up a broader and broader horizon, the rivers, big and swollen, wandered onward, bearing to the ocean the rain and snow of countless winters. Their basins filled with drift, they must have flowed along at heights far above where we now see them, shifting their channels unchecked by the hand of man, until they gradually wore them down, deeper and deeper, into their present grooves. Give them an infinity of time, and could they not spread out an infinity of gravel?

It is probable, therefore, that the rivers have had much to do with the formation of these beds; but still there are some features in connexion with them that river-action alone will scarcely account for. I do not see, for instance, how any river could so thoroughly scour out the drift as has been done in the narrower parts of most of the valleys and even in many of their wider portions, leaving in trough-shaped hollows not a trace of shingle or débris, and this in localities where, as I shall afterwards show, the mass of drift must have been immense, even some hundreds of feet deep. It may, however, be here objected that this clearing out of the drift has been the result of a later set of glaciers moving down the valleys after the period of the marine drift, and ploughing through that deposit. But had this been so, would not the glacier have pushed the drift before it in a rapidly accumulating hill, or thrown it on either side as is done by a snow-plough? In the one case we should expect to find some traces of these gigantic terminal moraines,—in the other, some relics of equally extensive lateral ones,—neither of which have I met with in those valleys I have examined. Further, if a glacier had thus ploughed through the drift, it would have left a ready-made groove for the rivers, so that we should not expect to find this gravel at the heights of 200 or 300 feet above the beds of the streams, as we often see it. Nevertheless I do not mean to deny the existence of glaciers *after* the marine drift, but only to say that I have not hitherto met with any satisfactory proof of their presence at this later period in the lower parts of our larger river-valleys, although, as will be subsequently shown, I do think there are grounds for suspecting their agency in such localities *previous* to the marine drift.

At all events there seems to be no trace of glacier-débris above this gravel; so that its origin is likely to have been subsequent to all such action, at any rate in the lower grounds.

Other objections which forcibly urge themselves against the supposition of the present arrangement of this surface-gravel being entirely due to river-action arise from the fact of its being occasionally piled up in great undulating mounds and tumuli 40 to 100 feet high,

the internal structure of which sometimes shows that their present form is not the result of denudation on what had formerly been a horizontally arranged deposit, but whose inward undulations conform to the exterior outline. And further, had the excavation of the drift been altogether owing to fluviatile agency, we should expect to find a greater concentration of large boulders along their channels, and also more evidence of river-meadows (or *haughs*, as they are called in Scotland) at high elevations, than what we see.

Then take a valley with a chain of lakes. These still sheets of water would arrest all the stones and gravel brought down by the stream from the valley above—in short, everything except the finer impalpable mud, and, where the lake was large and deep, even most of that. Now I think the signs of denudation in the neighbourhood of such lakes and in the valleys beneath them are much greater than we should expect on the supposition of mere river-action combined with a very gradual, slow emergence, like that supposed to be going on in Scandinavia at the present day. The "crag-and-tail" phenomenon before mentioned is equally inexplicable on a similar theory.

From these and other considerations which it would be tedious to dwell on longer, it therefore appears to me that the retreating action of the sea during the emergence of the land from the waters of the drift-period has borne a considerable part in the matter. The recession of this sea, caused by a strong earthquake-shock upheaving the land, would give rise to an action sufficient to account for many of those appearances which I have touched upon. Even the records of modern times show how often (we may say, indeed, how constantly) nature acts in this way, although, I think, it is going too far to suppose that the short space of time covered by the roll of history has afforded a complete insight into the operations of nature in this respect.

Multitudes of such shocks probably occurred as the land gradually struggled out of the sea; and the grating effect of the waters as they rushed back off the land would be sufficient to scour out the narrow ravines of the valleys, project the gravel out into the open spaces, and give rise to those appearances of "crag-and-tail" so frequently seen.

In the valley of the Dee this superficial water-rolled gravel is very well marked as far up as Invercauld, nearly 50 miles inland, and fully 1000 feet above the present sea-level. Further up the valley the underlying drift becomes of looser texture and of a more gravelly character, so that it is less easy to distinguish the two deposits.

§ 2. With regard to the boulder-drift, I had examined sections of it at many points between Banchory and Braemar, and found it extending all up the valley, everywhere possessing very similar features. No beds of brick-clay nor any great thickness of laminated sand had presented themselves between these two villages, which are upwards of forty miles apart, the former situated at an elevation of about 200 feet, the latter about 1130. Everywhere the drift seemed to rest immediately on the old rocks, and consisted of a hard tenacious mass of gritty mud, varying in tint from bluish-grey to pale brownish-

grey, studded thick with stones of all sizes, from the merest pebble up to blocks some tons in weight. Many of these (both the large and the small) are marked with parallel striæ and scratches in the line of greatest length. In these sections a large proportion of the stones and boulders are evidently water-worn, especially those of granite, which are sometimes as round as cannon-balls. I saw, however, but few traces of stratification in the drift between these two villages, although not unfrequently thin seams* of finely laminated silt did occur in various parts of the mass. I did not fall in with any clearly marked striæ on the rock-surfaces below the drift of this valley; but near a place called Brathens, in the neighbourhood of Banchory, I observed some of the humps of hard gneiss ground down very much on their western exposure.

The side glens frequently contain a great thickness of drift, generally of a looser and sandier character than that of the main valley; and the same is the complexion of the deposit along the Dee itself towards its higher part.

There are a multitude of glens that branch off from this river in the Braemar district, many of which I examined up to their extremities. In these mountain-valleys I found the steep hill-sides exhibiting little save their own rocky débris; but all along the midst of such depressions there was generally a considerable thickness of sand and gravel, full of stones and containing many large blocks.

In Glen Caich (or Glen Candlic, as it is sometimes called), which is situated on the east side of the granite mountain of Ben-a-Buird, I found this deposit spread over the whole bottom of the glen, rising to similar heights on both sides of the stream, its general depth where I examined it being from 30 to 50 feet. It consisted almost wholly of stratified sand and gravel, evidently well washed and deposited from water. Imbedded in various parts of it were many boulders of red granite like that of the neighbouring mountain; a few of them were from 7 to 14 feet in diameter. Some were rounded, some angular. Grooved or glacially scratched fragments appeared to be rare; for I noticed but one boulder showing them at all distinctly. Much of the deposit containing these blocks consists of *fine sand*, often laminated and containing along with the granite much débris of quartz-rock.

This spot was at an elevation of nearly 2000 feet, and is situated close beside Caich shooting-lodge at the head of Glen Sluggan. The same deposit is found all along Glen Caich (which is a branch of the Quoich), down to the valley of the Dee; it also extends somewhat further up the glen, but soon thins out; and about the base of Ben Avon the streams are found running along between bare slopes of crumbling granite.

There is another glen, which, commencing at Loch Etichan on the N.E. flank of Ben Muic Dhui, joins Glen Lui at the shooting-lodge of Lord Fife. This ravine is known as "*the Derry*."

Loch Etichan, by a sympiesometrical measurement of Prof. Dickie,

* These seams are scarcely ever horizontal, and are often curved in an odd manner.

is 2953 feet above the sea; it is encompassed by bare granite crags and blocks of the same nature. The stream issuing from it over the surface of these rocks makes a rapid descent, down a steep slope of perhaps 400 or 500 feet, into the glen below. Here there is a remarkable assemblage of mounds and tumuli, some of them reaching a height of 100 or 150 feet above their base (fig. 6).

Fig. 6.—*The Top of Glen Derry.*

1. Loch Etichan. 2, 2. Mounds of gravel.

No sections occur at this point to show their internal structure; but their steep slopes present shoals of gravelly débris, chiefly of granite: there are, however, many fragments of gneiss and laminated quartz, and even some of a hornblendic nature. This struck me as singular, seeing that the whole glen and mountain-group above, and their immediate neighbourhood, are believed to be exclusively of granite. If this opinion be correct, it tells strongly against these fragments being glacier-borne to their present position. Many of the quartz-fragments are partially water-worn. Some large boulders are scattered over the surface of these mounds, all of which, without exception, are of granite similar to that of the adjoining hills.

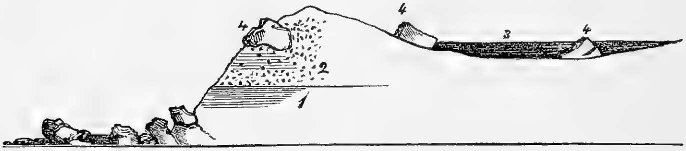
The deposit forming these mounds rises to corresponding heights on both sides of the stream, and continues down the glen for about half a mile or so, diminishing gradually in thickness until it ceases

rather abruptly at the head of a long narrow meadow about 300 to 500 yards wide that stretches down the glen for a mile or two, bounded on either side by bare hill-slopes destitute of any mounds. The upper limit of the mounds at the head of the glen is several hundred feet higher than the point where they cease at the top of this long meadow. At their termination here, they form a series of rough heathery hillocks 20 to 40 feet high, with many granite blocks upon their surface, through which the stream pursues a devious course.

At this point it had cut into some of them, exposing the internal structure and showing the upper part to consist for the most part of fine stratified sand (in many places almost as fine as sea-sand), derived from the disintegrated granite, of which some large boulders were imbedded in various parts of the mass as well as strewn more thickly on the surface. Small fragments of quartz-rock and a few of hornblende also were noticed.

Another section showed the base of one of these mounds to con-

Fig. 7.—*Section of a Mound in Glen Derry.*



1. Laminated silt. 2. Stratified sand. 3. Peat. 4, 4. Blocks of granite.

sist of a stratum of the *finest laminated silt*, of which a thickness of four feet was exposed, the laminæ being partly of fine sand and partly of clay capped by a bed of stratified sand with boulders interspersed, above which lay a stratum of peat with remains of decayed fir-trees. As these sections therefore showed the mounds to be evidently of watery origin, I concluded that they were not glacier-moraines, but the denuded relics of an aqueous deposit that had overspread the whole bottom of the glen from side to side, and that the greater frequency of the boulders on their surface arose from the washing away of a portion of the gravelly mass, concentrating these above them; while the termination of the deposit at the head of the flat meadow seems to indicate that it had been formed at the extremity of a lake whose waters had once extended to the top of the glen, and into which the mountain-torrent descending from Loch Etichan had washed down the débris.

Whether this former lake was fresh water or an arm of the sea may be questioned; but the great height of the mounds, the absence of any barrier below, and the fact that the upper limit of the deposit seemed to be higher than the watershed that divides the head of this glen from that of the Alt-Dhu-Lochan, whose waters descend into the basin of the Spey, seem all adverse to the idea of a fresh-water lake; while the circumstance of similar accumulations being general in all the glens of the district, together with the pre-

sence of transported boulders on mountain-tops at still higher levels, favour the supposition of a sea-loch having been the receptacle. I searched in vain for traces of Mollusca to decide this interesting question. Descending the glen, I found that, after reaching the lower extremity of the long narrow meadow, mounds again made their appearance; and a section of one of these near Derry shooting-lodge disclosed coarse stratified gravel containing well-rounded pebbles of granite. This second set of hillocks may be conceived to have arisen by the arm of the sea having retreated to near this point, when the stream from above would again commence to pour in its gravel and débris.

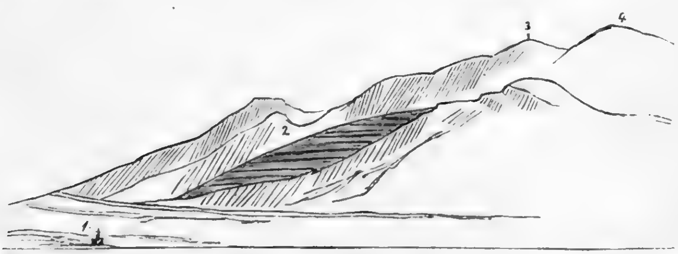
No striated or glacially marked stones occurred to me in these mounds of Glen Derry, *not one*, although I searched anxiously for them,—a circumstance that bears strongly against the theory of their being glacier-moraines.

It would be tedious to describe these things in the other glens of this district; suffice it to say that similar accumulations, evidently deposited from water, are of general occurrence in like situations in the various ravines of Braemar, up to the flanks of the central members of the great granite mountains of the Ben Muic Dhui group. I do not, however, mean to say that there are not also traces of glacier-moraines.

In Perthshire I examined some sections of the drift deserving special notice. Of these the most important was on the flank of a hill called Meal Uaine, about 2095 feet high, on the east side of the valley of the Tummel, just below Killiecrankie. It was remarkable for showing the immense thickness and height that the drift had attained in that quarter, as well as for the vast amount of denudation it has undergone.

Fig. 8.—*View of a Bank of Drift on Meal Uaine.*

W. E.

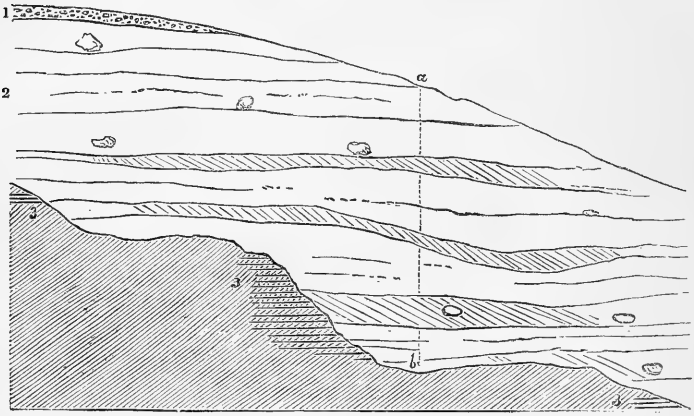


1. House of Fascally. 2. Bank of Drift. 3. Ordnance station. 4. Top of Meal Uaine.

The channel of the Tummel opposite this section is at an altitude, probably, of about 290 feet above the present sea-level; and on the base of the hill, for about 300 feet above this, the drift has been almost entirely swept away, little remaining on the surface of the rocks save a few patches of water-rolled gravel of more recent origin; so that we do not reach the foot of the section in question until we are at an elevation of about 600 feet above the sea, and 300 feet above

the river. From this point, then, the drift stretches up the slope of the mountain in one thick continuous mass to an altitude, exposed by the section, of nearly 1200 feet above the sea, but does not thin entirely out until it reaches an elevation of about 1550 feet. Two small streams descending the hill have laid open its structure. The northernmost of these ravines is by far the most satisfactory, giving a clean section down to the subjacent rock and extending through a vertical

Fig. 9.—*Section of Drift on Meal Uaine.* Depth of *a–b*, 130 feet.



1. Coarse stony stratum. 2. The stratified drift. 3, 3. The surface of rock with striæ.

height of 500 feet,—showing the mass to be regularly stratified in an almost horizontal manner, with occasional undulations; while its composition is seen to be much the same from top to bottom, consisting of numerous beds of the finest laminated silt, alternating with others, coarser and more stony, that show hardly any stratification-lines : large boulders from 4 to 5 feet in length are scattered through the whole. I also ascertained that it rested in all its extent on a rock-surface of gneiss, mica-slate, and quartz, which was grooved and polished as if by the passage of a glacier, while multitudes of both the small stones and large boulders imbedded in it were similarly marked.

In the channel of the rivulet were great numbers of blocks, that had, apparently, been derived from the waste of this bank of drift; some of them were from 8 to 14 feet in diameter, and many were grooved and furrowed.

The horizontal arrangement of the beds in this section would seem to indicate that they had originally occupied the whole width of the valley, in which case the thickness must have amounted to several hundred feet. It has been evidently all accumulated under water; and the great number of seams of fine laminated silt would seem to show that its deposition had been very gradual and had occupied a great lapse of time. These loamy layers are rather more numerous

in the lower part of the section, and are composed occasionally of an impalpable mud, like putty. No trace of shells occurred to me, although I searched for them narrowly in several parts. Some of the fine sandy matter, when examined through a magnifying lens, was seen to consist chiefly of small rounded grains of quartz, together with an impalpable powder of apparently decomposed felspar.

There were no beds of clean-washed gravel or shingle—all was more or less earthy; neither was there a great thickness of pure clay in any part; and the general tone of the whole was very similar throughout, varying from pale yellowish-grey to brown. I observed that some of the finer loamy seams had been partially washed away before the deposition of the superincumbent layers.

The topmost stratum of this bank consisted of a coarser, stonier mass, 3 to 5 feet thick, which seemed to me to have resulted from the denuding agency that had swept away the drift; for it differs from the subjacent beds chiefly in having the finer matter washed out. The stones so plentifully dispersed in the drift consisted for the most part of mica-slate and gneiss, together with some of granite, hornblende, porphyry, and crystalline limestone.

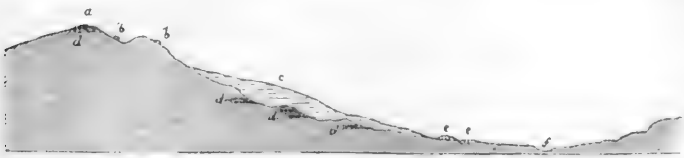
Now, as this great bank of earth contains probably several thousands of fine laminæ of clay and sand imposed one above another in regular succession, separated by many beds of a coarser description, I think the notion of such a mass having been thrown together by any sudden convulsion becomes inconceivable, while the fact of its upper limit overtopping all barriers between it and the sea is equally decisive against a fresh-water origin; and, furthermore, that its whole structure belongs to the latest tertiary period is shown from its reposing throughout its entire extent on a glacially polished rock-surface. Here, then, we have—

1. A gradual formation.
2. A marine origin.
3. A Pleistocene age.

And thus I think there are proofs that in these later times the sea-waters had assuredly rolled for many centuries over the hills and valleys of Scotland.

If I am correct in assuming, from its horizontal stratification, that

Fig. 10.—*Section across the Tummel Valley at Meal Uaine.*



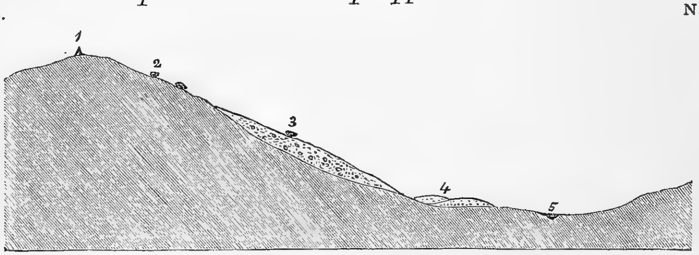
a. Top of Meal Uaine. *b, b.* Boulders of granite and porphyry. *c.* Bed of Drift. *d, d.* Striæ on the rock. *e, e.* Water-rolled gravel. *f.* The Tummel.

the deposit of which this bank is a portion had originally extended all across the valley, then it is evident what an enormous denudation has taken place; for we have here but a patch, which owes its preser-

vation to the sheltered position it occupies in the bosom of the hill between two projecting buttresses of rock. Not a trace of drift remains on the slopes of mica-slate on the opposite side of the river; all has been swept away.

Between Loch Tummel and the valley of the Tay, there lies a great ridge of mica-slate stretching in an east and west direction, with numerous peaks reaching from 2000 to 2600 feet high. The drift on the northern slope of this ridge stretches up to a height of 1500 feet.

Fig. 11.—*Section across the Ridge of Mica-slate, showing the Drift upon its Northern Slope opposite Bonskeid.*



1. Ordnance station (2015 ft.). 2. Boulders. 3. Boulder-drift. 4. Water-rolled gravel. 5. The River Tummel.

I descended the course of a small rivulet that joins the Tummel opposite the House of Bonskeid, and which has cut through the earthy covering in such a manner as to afford a good view of its structure. Having an aneroid with me, I took measurements as I went along, and found that the upper limit of the drift lay at an altitude of about 1520 feet. At 1494 feet it was 16 feet deep, resting on a smoothed rock-surface showing grooves and striæ pointing N. 20° to 30° W. At 1424 feet the thickness had increased to 30 feet; and at 1005 feet the drift reached a depth of 50 to 80 feet, resting on coarse gneiss, showing parallel furrows and scratches pointing N. 70° W. It continued of considerable thickness for some distance further down; but below 700 feet it almost entirely disappeared, as if it had been washed away; and at 612 feet the loose water-rolled gravel made its appearance, resting on some denuded remains of the drift, of which there was a patch left some ten feet thick. This was 185 feet above the bed of the Tummel at the mouth of the rivulet.

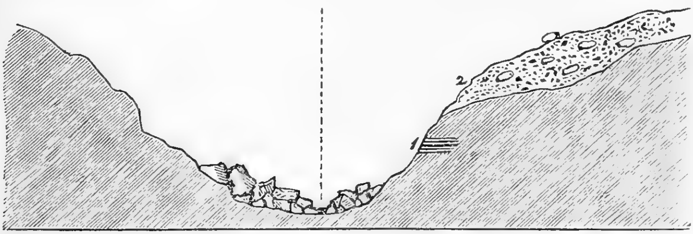
It will be remembered that the drift on the flank of Meal Uaine was cut away at a similar height, and that water-rolled gravel made its appearance there also a little beneath its lower limit. In these instances, therefore, I think we have evidence that the drift has been subjected to great denudation, and that in the water-rolled gravel we have traces of some of the forces that effected it.

§ 3. At an elevation of 1485 feet, in a small rocky hollow in the course of this stream, where the drift had mostly been removed, I found the vertical sides of the rock fluted, grooved, and scratched almost horizontally, the markings pointing due north.

These furrows were not quite horizontal, but sloped somewhat with the inclination of the ridge, the north ends pointing down towards the Tummel.

Land-ice sliding down the hill might give rise to these markings, or floating ice coming from the north during the submergence of the country; but no glacier moving down the Tummel could effect them, as the direction of that valley is here E. and W.

Fig. 12.—*Section across the Bed of the Stream, showing striæ on the vertical surface of the rock.*



1. The striæ. 2. Drift.

In the valley of the Tay at Aberfeldy, I noticed striæ and grooves on the gneiss below the drift, a short way up the banks of the stream that gives rise to the well-known Falls of Moness. Now the direction of this stream is here almost N. and S.; whereas the glacial furrows pointed due W., conforming to the strike of the main valley of the Tay.

With regard to the striated rock-surface beneath the great Pleistocene bank on Meal Uaine, the direction of the grooves and furrows also coincided with that of the main valley in that quarter, their strike being N.W. and S.E., transverse to the course of the little rivulet, and also to the strike of the rocky strata, which is here N. 60° to 70° E., dipping almost vertically.

Sometimes these grooves ran horizontally along the face of the humps of rock, which were much ground down and rounded off. Where the strata were of coarse quality, the markings consisted of rude scores and furrows; while the harder, fine-grained quartz was polished until it glanced again, with numerous fine, needle-like scratches, coinciding in their general direction with the scores on the coarse gneiss.

Now, as the situation of these markings in this case is in a deep sheltered hollow, protected both to N. and S. by protruding buttresses of rock, it struck me forcibly that no floating iceberg could well have effected them, for it would have grounded on these projecting ridges; while it seems further difficult to conceive how any large island of ice could have approached at all from the N.W., so environed is the spot by hills in that direction.

Altogether it seemed to me more like the action of a glacier that had occupied the valley *previous* to the marine drift, and whose plastic mass could adapt itself to all the sinuosities of the surface;

and such an agency seemed further indicated by the fact that the grooves and striæ on the vertical faces of the rock are seldom quite horizontal, but very generally dip somewhat to the southward; that is to say, they *slope with the valley*. Again, it is evident that under glacier-conditions this is precisely a spot where immense grinding action would be exerted; for the two Highland valleys of the Tummel and the Garry here unite, so that there would be a convergence of two great ice-streams at this point, hemmed into a narrow valley by high ridges on either side.

Ascending the shoulder of this hill of Meal Uaine above the bed of drift previously described, I found the hard quartzose strata along its western side remarkably rounded off in many places, and ground down into smooth bosses, while occasional boulders of porphyry and granite lay here and there on the surface.

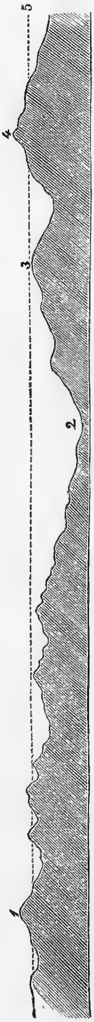


Fig. 13.—*Section along the Ridge of Mica-slate.* Distance 10 miles.

1. Farragon. 2. Bed of the Tummel. 3. Meal Uaine (2095 ft.). 4. Ben Bhrackie (2800 ft.). 5. Level of the top of Meal Uaine.

But what surprised me still more, on gaining the top of the hill I found the stamp of the ice there as vivid as in the ravine below. The coarse, hard, gnarled gneiss that forms the scalp of the ridge has all its angularities ground off, and is fluted with long scooping depressions, across the seams of the strata, and pointing N. 45° W. (N.B. These bearings are all *true*, and *not magnetic*.) These fluted portions are smoother than the rest of the surface, although all is rounded off. This is on precisely the highest point of the summit. Thinking that there was still a possibility of these appearances being due to structure, or other causes, I searched about, and soon noticed other scores and furrows a few yards lower down, pointing N. 40° W. Again, 60 feet below the summit, on the *southern* brow of the hill, I came upon some surfaces showing the most unmistakeable polish, striæ, and scratches, together with scores and larger furrows, all parallel, and also pointing N. 40° W. The rock is here of an extremely hard and tough nature, to which is doubtless owing the preservation of these markings.

It thus appeared that the whole flank of the hill is marked from top to bottom; for I had detected these impressions at altitudes varying from 750 feet up to the summit, which by aneroid measurement I made 2095 feet high.

I have already said that the polish on the flank of this hill underneath the drift strongly suggested the idea of glacier-action; now as the striæ and furrows on the crest of the mountain are precisely coincident in their direction, there is a presumption that both are due to the same agency. If, then, we adopt the instrumentality of a glacier, we are driven to the admission that it must have been of

altogether gigantic dimensions; for after deducting 300 feet for the bottom of the valley, we still have left 1800 feet to reach the top of this Meal Uaine. If, again, we take refuge in the supposition of floating ice, we must invoke a submergence of at least 2100 or 2200 feet; for our iceberg must have some depth of water to swim in.

Here then is a dilemma, either raise the coast-line 2200 feet, or fill up the valley with an ice-stream 1800 feet deep.

It is possible however that a glacier may have caused the markings low down the hill, and floating ice those on the top; although in this case the coincidence of direction in the moving agent is singular, and the fact of markings on the *south* brow of the hill also curious. It is clear, however, that immense force must have been in operation; for the rock on the top is one of the most obdurate to be met with, being a rugged gneiss full of quartz-veins. No force of water alone could, I think, have left such a handwriting on stuff of this adamantine texture.

The adjoining mountain, Ben Bhrackie, reaches a height of about 2800 feet; and over its summit the rock is not thus rounded, but has disintegrated into numerous blocks, that lie thickly all about.

This may perhaps be partly due to the different quality of the strata, which are very hornblendic. However that may be, I did not remark any smooth bosses of rock until I had descended the N.W. slope to an elevation of about 2220 feet; but no grooves or glacial furrows occurred to me.

Several miles to the west of this, near Hioch Vore, on the mica-slate ridge before mentioned, I had observed, on one of its northern slopes, at an altitude of about 2220 feet, a hump of the rock remarkably smoothed and ground down, and covered with parallel striæ and furrows pointing N. 70° to 80° W. and transverse to the laminæ of the strata.

§ 4. All along the northern slope of this ridge, from Meal Uaine at one extremity, westward for ten miles to Hioch Vore at the other, I had remarked many boulders of granite and porphyry at heights exceeding 2000 feet, the highest being one of granite, that lay at an elevation of 2390 feet (by aneroid). These boulders seldom exceeded two feet in diameter, and were generally smaller. The highest which I had noted on Meal Uaine was at 1960 feet. They are also not unfrequent in the high-lying drift along the north slope of these hills.

Now I examined the greater part of that ridge, crossed it at several points, and walked along its crest for miles, but saw no indication anywhere of this granite or porphyry *in situ*. I think therefore I am justified in concluding that they have been carried to their present position from a considerable distance; and knowing that such rocks occur in the high mountains situated to the northward (as, for instance, in those of Glen Tilt), I think it is further probable that *there* lies the source from whence they have come.

But it is not at 2000 or even 2400 feet that we cease to find such transported fragments, for in the Braemar district I met with them much higher.

A remarkable instance of this occurred on the Hill of Morven, a

few miles to the north of the village of Ballater. The average of four different measurements makes the height of it 2953 feet above the sea, the highest value being 3048. It stands many miles apart from any hill of like elevation; in fact, there is none so high within ten miles; and it greatly surpasses any eminence to the N. and E. between it and the sea. All the upper part of the mountain, so far as I could ascertain, is composed of one sort of rock, which seems to be a mixture of greenish hornblende and white felspar, showing no stratification-lines. No gneiss, quartz-rock, or granite came under my notice, although the last-mentioned rock occurs about its base. The late Professor Macgillivray had, I find, examined the hill, and pronounced it to be of hornblende-rock. It was therefore with no small degree of wonder that I remarked several rounded boulders of granite, together with some of quartzose gneiss or laminated quartz, lying here and there on the western brow of the mountain; and I traced them up to the very summit: one or two of them, indeed, are built into the prop or cairn that marks the highest point. The largest of these fragments did not exceed two feet in diameter.

This then is surely a most remarkable fact: for if we assign the agency of floating ice for the transport of these boulders, perched up here amongst the mist and Ptarmigan, we must admit a submergence to the extent of 3000 feet; and yet no other feasible theory has been offered that can account for such facts.

Again, there is a hill close to the village of Braemar named Cairn-a-Drochet, reaching an elevation of 2703 feet, according to Mr. Robertson, author of a large map of Aberdeenshire; while an aneroid measurement of my own made it 2655. Seventy yards to the north of the cairn that marks the summit, and at a level 20 feet lower, there sits a block of coarse red granite 12 feet in length; while many boulders of the same kind are scattered all around. Now the upper part of this hill is chiefly composed of quartzose gneiss, intersected with dikes and masses of felspar-porphyry; and although granite also occurs *in situ* a short way down the hill, yet it is of a different quality from this block, containing a much smaller proportion of quartz, while the felspar is of a paler tint; and upon the whole I think it likely that this block and many of the other boulders near it have been derived from the mountains to the north, the granite of which is identical in character. Still I do not mean to press this too strongly, but would only remark that the fragments of quartz, felspar-porphyry, and granite on the flat top of this hill are mingled together in such a way as to indicate exposure to some shifting agency, as if they had been washed about together while under water. The felspar-fragments are mostly small and angular, the quartz often partially rounded, and those of the granite frequently quite rounded.

The only other instance of high-lying fragments, apparently transported from a distance, that I shall here adduce, relates to a mountain called Ben Uarn More (3589 feet). It forms the culminating peak of the great ridge that divides the shires of Aberdeen and Perth, and is composed of quartz-rock, showing a laminated structure. No other rock occurred to me as I clambered up the steep northern slope;

but I observed here and there, as I went along, fragments of a peculiar kind of porphyry that I had met with *in situ* on a lower ridge to the northward. These fragments continued to occur, although very sparingly, high up on the shoulder of the mountain; but on the very top I looked some time for them in vain. A prop or cairn on the summit, apparently the work of the Ordnance Surveyors, showed nought but quartz, the sharply angular débris of which strewed the protruding edges of the strata, clothed here and there with a carpet of fine soft moss, the last stunted patch of heather having failed considerably lower down. A single Alpine Hare was the only living creature I saw on this lone mountain. Searching about amongst the quartz-débris I did, however, find, on the very top of the hill, a small lump or two of the same porphyry; and other fragments of it occurred as I descended the shoulder of the mountain. Although a dike of this porphyry may run through some part of the hill, yet I think I may safely say it does not appear on the very crest; for, owing to the absence of vegetation on the sterile siliceous rock, the strata are so bare that I could scarcely have missed seeing it: and if any vein of it did occur, its fragments ought to be much more numerous; for, as I have mentioned, it was only after some scrutiny that I could detect some two or three pieces. I question, indeed, whether any such porphyry now exists at so high an elevation in this part of Scotland.

Perhaps the most probable supposition with regard to these and other like cases is, that ridges of the absent rock may have originally existed at greater heights, and that such fragments have been scattered about during the denudation that has gone on in earlier geological periods. Still, looking at the numerous instances of high-lying boulders that have undoubtedly been transported during the Pleistocene epoch, we cannot help speculating on the probability of these also having been lodged where they now lie during the same period.

And in connexion with this I may here remark that I found no foreign fragments on the tops of the granite mountains of the Ben Muic Dhui group that attain elevations approaching 4000 feet and upwards. Some of these I examined narrowly with this especial view, particularly the extensive table-like summit of Ben-a-Buird, where I thought, if anywhere, they might be found. But nothing met the eye save granite blocks and granite sand, with occasional pieces of white quartz, veins of which are common in these mountains.

§ 5. One circumstance struck me as worthy of notice in reference to the dispersion of blocks from these granite hills. They lie in a great cluster on the north side of the River Dee; while to the south of its valley rises a chain of quartz mountains of considerable magnitude, intersected by numerous glens. On the theory, then, of a transport due to floating ice urged by a current from the north, it was to be expected that many of these granite blocks would pass across the valley on their ice-rafts, and be arrested on the higher parts of this quartz chain immediately opposite. Accordingly, in traversing some of the principal members of the group, viz. the Glas Meal, Cairn-na-

Clasha, Ben Uarn More, and Gelly Cairn, I kept a constant look-out for granite boulders, and was much surprised to find none (not even one) on any of these hills, nor, as far as I remember, in the glens between them, of which I traversed Glen Cluny, Glen Ey, Glen Conny, and Glen Kristy. On the large mass of the Glas Meal I noticed many boulders that presented a reddish granitic aspect; but on breaking them up, found them to be of a felspathic porphyry quite different from the coarse red granite of the Ben Muic Dhui group. It was only towards the mouth of Glen Ey that I noticed some of granite. Now this is very remarkable on the supposition that the blocks have been transported by floating ice, but would be quite intelligible on a glacier-theory; for large boulders from these mountains are numerous in the valley of the Dee, and in the glens and hills on the north side of that valley to the eastward of the granite-masses. It is possible then, and perhaps probable, that the land-ice has played a considerable part in the conveyance of the larger erratic blocks from many of our mountains, although I am far from restricting their transport entirely to such means.

That there had been an extensive development of glaciers and land-ice *previous* to the marine drift is, I think, likely from various considerations. The absence of all earlier tertiary deposits, and the fact of the drift resting so generally on the polished and striated surface of the old rocks, without the interposition of any other beds, bespeaks something singular in the previous history of the surface.

No trace of lacustrine mud, fluviatile gravel, or buried forests, testifies the pre-existence of ordinary land-conditions; and it is almost inconceivable that any advance of the sea, whether gradual or sudden, could have so utterly annihilated all trace of these, especially in the inland valleys, where the waters would have assumed the character of quiet sea-lochs, such as now indent the west coast of Scotland. But if we assume a long period of land-ice, with glaciers grinding down along the valleys for ages, and sludgy sheets of ice, like those of Greenland, overspreading the rest of the surface, the absence of all such remains becomes more intelligible. And when we further consider that the character of the Mollusca of the English Crag-formations indicates clearly a progressive diminution of temperature *previous* to the marine drift (as is so well brought out by the abstract of Mr. Wood's labours drawn up by Sir Charles Lyell in the Supplement to the last edition of his 'Elements of Geology'), we have some warrant for concluding that such may have really been the case.

The unstratified boulder-earth that occurs beneath the marine beds of the Clyde and other districts may therefore, under this view, be glacier-débris or moraine-matter levelled by the advancing sea-waters of the drift-period. The immense profusion of transported blocks and striated pebbles in many localities is more favourable to the idea of glacier-action than of floating ice (for in some localities almost every pebble is striated), as is also the pell-mell and hodge-podge mixture of the fragments in the earthy mass. I have likewise shown that the polished rock-surface beneath the drift is in certain cases almost

inexplicable by floating ice, but perfectly accordant with glacier-action. Again, there are localities where the blocks have been carried northwards, as was shown by Sir R. Griffith with regard to those proceeding from the Ox Mountains in Ireland (Brit. Assoc. Report, 1843, Sect., p. 41),—a circumstance opposed to the idea of a southward-drifting marine current. And in districts where the marine drift is charged with remains of Arctic *Mollusca*, it would appear that there is very often a considerable thickness of unstratified boulder-earth beneath it, which is quite destitute of the slightest trace of marine fossils, but studded thick with striated boulders and pebbles, like the matter of a moraine.

The many instances I have adduced of high-lying stratified drift and transported boulders at elevations exceeding 2000 feet, indicate an almost total submersion of the country; and the observations of geologists in many other parts of Britain tend to the same conclusion.

The late Mr. Trimmer, who had paid much attention to the English Pleistocene, inferred from his many observations that almost all England had been covered (Journal of Geol. Soc. vii. p. 26); while the researches of Professor Ramsay in Wales point to a similar result for that region (*ibid.* viii. p. 372). Mr. Darwin, likewise, reasoning from the presence of a large syenitic boulder on the top of Ashley Heath in Staffordshire, and from other facts, decided that the whole of that region was, at the period of floating ice, deeply submerged (Ed. New Phil. Journ. xxxiii. p. 352). Professor Phillips, in like manner, finds proof that every part of Yorkshire below the level of 1500 feet was covered by the waters of the same glacial sea (Brit. Assoc. Report, 1853, Sect., p. 54). And I might go on to quote the many instances of high-lying boulders in the south of Scotland adduced by Maclaren, Chambers, Nicol, and others: while in the west the same occurs; for Mr. Darwin, in his account of the Parallel Roads of Glen Roy (Phil. Trans. 1839), mentions having observed boulders of granite on Ben Erin up to an altitude of 2200 feet. And I may here mention, generally, that in the Highlands of Perthshire and Aberdeenshire I found the presence of far-travelled boulders at heights exceeding 2000 feet by no means uncommon,—that, indeed, it was rare to find any extensive ridge without them. The above shows that this great submergence was not local, but general over Great Britain.

§ 6. There are only some dozen or so of hills in England, Wales, and Ireland that rise above 3000 feet; and the highest of them all, Snowdon, falls short of Ben Uarn More, where I noticed the transported fragments of porphyry. Without, however, meaning to lay much stress on such isolated cases, I think the tendency of the evidence points to an extent of submergence during the drift-period that must have quite extinguished all the larger *Mammalia*; and, as no upper limit has yet been established, perhaps it may have been so complete as to annihilate all terrestrial life in these islands.

In the central Highlands of Braemar the higher mountains are generally remarkable for tremendous precipices on their sides, most frequently on their eastern flanks. Some of these stupendous cliffs

rear a perpendicular front of 1000 or even 1500 feet, as at Lochnagar and Cairntoul; and it will be found that their base is frequently at an altitude of 2200 to 2500 feet. Wandering along these lofty walls of granite, the thought sometimes struck me that in them I saw the ancient sea-cliffs of this glacial sea, and that here its chill waves were staid. Afterwards, on looking over the beautiful plates of Professor Forbes's book on Norway and its Glaciers, I was impressed with the resemblance of some of the scenes along that iron-bound coast to the rocks and corries of these Highland mountains.

In order to obviate the objections that naturally arise against such a change of level as I have hinted having taken place in a geological period comparatively so recent, I may call to mind that the marine Pliocene of Sicily rises 3000 feet above the present coast-line; and further, that Sir Roderick Murchison and other eminent geologists invoke a like change of level for the Alps (Geol. Journ. vi. p. 66).

The conclusions which I have above drawn might lead to a very interesting inquiry as to how the present flora and fauna overspread the country; for there can be little doubt that their introduction, as a whole, dates from the close of the marine-drift-period. But this would be quite beyond the scope of the present paper; and I shall only point out how highly desirable it is that a clear distinction should be made between the group of *Mammalia* of the period antecedent to the drift from that of the period which followed it in this country: for it would seem to be the case that the two assemblages, although both geologically of recent date, are yet severed by a long stretch of time.

§ 7. Combining the observations of this and my former paper, I am inclined to think that the following course of events may be descried in the Pleistocene history of Scotland.

1st. A period when the country stood as high, or greatly higher than at present, with an extensive development of glaciers and land-ice, which polished and striated the subjacent rocks, transported many of the erratic blocks, destroyed the pre-existing alluvium, and left much boulder-earth in various places.

2nd. To this succeeded a period of submergence, when the sea gradually advanced until almost the whole country was covered. This was the time of the marine drift with floating ice. The beds with arctic shells also belong to it; and some of the brick-clays are probably but the fine mud of the deeper parts of the same sea-bottom.

3rd. The land emerged from the water, during which the preceding drift-beds suffered much denudation, giving rise to the extensive superficial accumulations of water-rolled gravel that now overspread much of the surface. This movement continued until the land attained a higher position than it now has, and became connected with the continent of Europe: its various islands were probably also more or less in conjunction. The present assemblage of animals and plants gradually migrated hither from adjoining lands. Glaciers may have still formed in favourable places, but probably never regained their former extension.

4th. The land sank again until the sea in most places reached a

height of from 30 to 40 feet above the present tide-mark. Patches of forest-ground were submerged along the coast. The clays and beds of silt, forming the "carses" of the Forth, Tay, and other rivers, were accumulated, as well as the post-tertiary beds described by Mr. Smith of Jordanhill (Trans. Geol. Soc. vol. vi. p. 153), the shells of which agree with those of our present seas.

5th. An elevation at length took place, by which the land attained its present level. As Mr. Smith has shown (see Werner. Soc. Memoirs, viii. p. 57), this probably occurred before the Roman invasion; but that Man had previously got into the country appears from the fact of the elevated beds of silt near Glasgow containing overturned and swamped canoes with stone implements (see Brit. Assoc. Report, 1855, Sect., p. 80).

On the Occurrence of Crag Strata *beneath the* Boulder-clay *in* Aberdeenshire. By T. F. Jamieson, Esq.

[Communicated by Sir Roderick I. Murchison, V.P.G.S., &c.]

[Read June 13, 1860, but, by permission of the Council, printed here in association with the foregoing paper, which has reference to the same district.]

In the parishes of Slains and Cruden (see Map, p. 348) we have beds apparently of the same age as the English Crag formation. They consist of stratified sand and gravel underneath the boulder-clay, and reposing upon the old rocks of the district. I need not enter into any description of the locality in which these deposits occur, nor of their general character, as these will be found detailed in a paper on the Pleistocene of Aberdeenshire, which the Geological Society did me the honour of printing in the 14th volume of their Journal (see pp. 522–525).

I had even at that time some suspicion of their Crag character, from their position below the boulder-clay, and, further, from the total absence of any glacial striæ or polish upon the pebbles: but I have since then made a close search amongst the comminuted shell-fragments that are everywhere sparingly scattered through the mass; and it is from the character of these, combined with the geological position of the strata, that I infer the age to be probably that of either the Red or the Mammaliferous Crag of England.

I have upwards of a score of hinge-fragments which I can safely refer to the *Cyprina rustica* or *Venus rustica* of Sowerby's 'Mineral Conchology'—a shell which is unknown in the drift-beds, and which, so far as I am aware, has been found only in the Crag; likewise a few fragments of the *Fusus contrarius*, another Crag form.

The prevailing species of *Pecten*, so far as I can judge from the small pieces I have collected, is the Crag variety of *P. opercularis*, viz. *P. opercularis*, var. *Audouini*. Some of the species of *Astarte* appear also to belong to *A. Omalii*; and the only specimen of *Purpura* is a Crag variety of *P. lapillus* (viz. *P. lapillus*, var. *incrassata* of S.

Wood), allied in appearance to *P. tetragona* (otherwise *Murex alveolatus*).

The following is a list of the shells, so far as I have been able to decipher them from their broken and water-worn fragments :—

Cyprina rustica. Not very uncommon.
C. Islandica. Very common, being the most plentiful shell of the deposit.
Astarte. Apparently several species; but the condition of the fragments renders their identification difficult.
Venus. Apparently of more than one species; but, judging from the hinge-pieces, *V. casina* is the most common.
Artemis lincta. A few fragments.
Cardium. Not uncommon, and of more than one species, some of them of large size.
Pecten. Several species. The most common, so far as I can make out from the remains, seems to have been *P. opercularis*, var. *Audouini.* One small bit looks like *P. maximus,* while the ribbing of another is more like that of *P. princeps.*
Pectunculus glycimeris. Common; and it seems to have attained a good size.
Tellina solidula. Of some specimens sent to Mr. S. P. Woodward two years ago, he wrote me, "There are two specimens of the *Tellina* of unusual thickness. Mr. M'Andrew would scarcely believe it this species (*T. solidula*); but it is like no other."
Mya, apparently *M. truncata.* One or two pieces.
Fusus antiquus. Not very uncommon.
F. antiquus, var. *contrarius.* Three or four fragments.
Mangelia, like *M. turricola,* but distinct. One specimen.
Purpura lapillus, var. *incrassata* of S. Wood. One specimen.

Besides these, I have fragments of other species which I have not yet been able to identify. The whole of those above enumerated are found in the Crag of England; while the character of the group is different from the usual assemblage met with in the drift-beds of this part of Scotland. For instance, *Pecten Islandicus* is the only *Pecten* I have found in the drift; and none of the fragments from these supposed Crag beds appear to belong to it. We miss also *Tellina proxima, Natica,* and other common drift-shells.

The materials of the strata are all very much water-worn, and indicate long rolling about in a shallow sea. The shells have suffered similar treatment, and are accordingly so broken and worn as to render their identification very difficult. I have gathered hundreds of fragments, but have never yet got one perfect specimen. Some of the pieces are filled with a hard stony crust; and occasionally indurated calcareous nodules are met with full of comminuted shells. Owing to the covering of drift, however, the beds are very badly exposed; but the mass in many places reaches a thickness of 30 or 40 feet, and in some cases a good deal more.

If I am right in referring this sand and gravel to the age of the Crag, it will throw some light upon the origin of our chalk-flints;

for, as flints are common in these beds, it would show that they could not have been drifted hither during the glacial period, but must have existed in the district before.

In addition to the flints, these so-called Crag beds contain great quantities of limestone-fragments, apparently derived from secondary strata, and unlike any rock I have seen hereabouts. Some of them are of a yellow, others of a smoke-grey colour; they are of a tough, compact, earthy texture, and often finely laminated. Organic remains are rare in them, but do occur. A day or two ago I struck open a cast of a *Terebratula* in one, and a small elongated species of *Mytilus*, and have seen the impression of a little Fish in another. The aspect of the *Terebratula* suggests a Permian age; and the general character of the fragments altogether seems to resemble that of the Magnesian limestone. Where they came from, however, is a mystery.

There are also many fragments of red and grey sandstones—all whispering, as it were, of some great denudation that has taken place in the surrounding region.

P.S. [*September 24th*, 1860.]—Since the above was written, Mr. Searles Wood, whose monograph on the Mollusca of the Crag has associated his name so indissolubly with that subject, has done me the favour of examining the fragments which I had collected from these beds. He agrees with me in thinking that, altogether, they have decidedly a "Crag" aspect; and, "on the whole," he says, "I think you are justified in assuming that the Red Crag sea extended itself into your neighbourhood."

Mr. Wood has also identified the following additions to the above list of Mollusca:—

Nassa reticosa, var. *rugosa*. "A truly characteristic fossil of the Red Crag."
Pholas. Several fragments.
Glycimeris? Two fragments.

I would fain say a word or two as to the probable cause of the preservation of this patch of Crag; for the thickness of the mass shows it to be the remnant of a more widely spread deposit; and it is remarkable that not a trace of it is seen in the adjoining valley of the Ythan. There must, therefore, have been some peculiar reason why it was left here only and nowhere else. Now, I have frequently remarked that the locality is one that during a glacial epoch would be singularly out of the way of the movement of *land-ice* under the most frigid climate that could be supposed, and one also remarkably secure from the destructive effects of off-rushing water during movements of upheaval. I cannot, therefore, avoid thinking that its preservation may have been due to this favourable position during the vicissitudes of the Drift-period.

February 17, 1860.

Annual General Meeting.

[For the Reports of the Council, &c., see the commencement of this volume.]

February 29, 1860.

William Smith, Esq., C.E., Salisbury Street, Adelphi; and C. A. Sanceau, Esq., F.C.S., Blackpool, Lancashire, were elected Fellows.

The following communication was read:—

On the Zone *of* Avicula contorta, *and the* Lower Lias *of the* South of England. By Thomas Wright, M.D., F.R.S.E., and F.G.S.

Contents.

§ I. *Introduction.*—Although the Liassic formation of England and Wales attains a development equal in many respects to that of

the Lias in any other land, both as regards the sequence of its different zones of life, the richness of their faunas, and the fine preservation of the animal remains contained therein, still the stratigraphical relations of these subdivisions, with the range and distribution of the species in time and space, have not received from English palæontologists that measure of attention bestowed by the geologists of the Continent on the Lias of their respective countries. In consequence of this neglect, the correlation of many of our Liassic beds with others of the same age on the Continent of Europe has not been satisfactorily made out, and requires re-examination.

Having during the summer of 1859 made excursions to several of the most typical localities in the counties of Warwick, Gloucester, Glamorgan, Somerset, and Dorset, with the view to determine the stratigraphical relations of certain beds of the Lower Lias containing *Echinodermata*, I had the satisfaction of discovering, in this search, the true position of the Saurian-bearing beds at Street and their relation to the Ammonitiferous beds of the Lias, and finding the *Avicula contorta* beds,—the equivalent of the Upper St. Cassian beds and "Kössener Schichten," which have so long engaged the attention of foreign geologists, thus establishing important palæontological correlations with a series of Continental deposits,—the Kössen strata, of great interest in both Triassic and Jurassic geology.

Boundary of the Avicula contorta *beds and the Lower Lias.*—In the zone of *Avicula contorta* I include all the black shales with their interstratified sandstones, limestones, and Bone-beds which lie between the grey, green, and red marls of the Keuper, and the lowest *Ostrea* beds in the zone of *Ammonites planorbis*; and in the Lower Lias I include all the marls, clays, and limestones lying between the *Ostrea* beds at the base of the zone of *Ammonites planorbis*, and the clays containing *Ammonites raricostatus*, and the upper beds of the same zone, charged with *Hippopodium ponderosum*, *Gryphæa obliqua*, and *Cardinia Listeri*.

In the Table at p. 376, I have arranged the zone of *Avicula contorta* with the different zones of the Lower Lias, and, in parallel columns, have added the designations by which some of these groups are distinguished by British geologists.

[TABLE, *over*.

The Avicula contorta *beds and the Subdivisions of the Lower Lias proposed in this Memoir, compared with the Classification of the same strata adopted by other British geologists.*

	Ammonite-zones adopted in this Memoir.	Sir R. Murchison's 'Geology of Cheltenham.'		Sir H. De la Beche's 'Section at Lyme Regis,' Geol. Trans. 2 ser. vol. ii.	Rev. W. Conybeare's 'Geology of England and Wales.'
THE LOWER LIAS.	*Zone of* AMMONITES RARICOSTATUS.	Hippopodium-bed. Cardinia-bed.	Lower Lias Shales (in part).	Upper Marl (in part).	Upper Marls.
	Zone of AMMONITES OXYNOTUS.	Ammonite-bed.			
	Zone of AMMONITES OBTUSUS.				
	Zone of AMMONITES TURNERI.				
	Zone of AMMONITES BUCKLANDI.	Plagiostoma-beds.	Lower Lias Limestones and Shales.	Blue Lias. Limestone.	True Lias Beds.
	Zone of AMMONITES PLANORBIS.	Saurian-beds. Insect-limestone.		White Lias.	
KEUPER.	*Zone of* AVICULA CONTORTA (*upper part of the* KEUPER).	Bone-bed.		Lower Marl.	Lower Marls.
		Red or Keuper Marls.		Red Marl.	New Red Sandstone.

§ II. THE ZONE OF AVICULA CONTORTA.

Von Buch, "Schicht mit Gervillien auf der Gruber Alp am Setzberge in den bayr. Alpen," Denkschr. Akad. Wissensch. Berlin, Jahrg. 1828, p. 82. Alberti, "Versteinerungsreicher Sandstein von Täbingen," 1834. Strickland, "Calcareous Sandstone with Pectens, and White Micaceous Sandstone with bivalve shells," Proceedings of the Geological Society, 1842, vol. iii. p. 586. Portlock, "Shale" with *Avicula contorta*, and "loose gritty marl" containing *Pecten Valoniensis*, Report on Geology of Londonderry (1843), pp. 126, 127. Brodie, "Pecten-bed," Fossil Insects of the Secondary Rocks (1845), p. 58. Quenstedt, "Gelbe Sandsteine," Flözgebirge Württembergs, 1846. Emmerich, "Gervillien-Schichten," Neues Jahrbuch, 1849, p. 437.

Schafhäutl, "Schiefergebilde der Wetzsteinformation mit Gervillien," Geognost. Untersuch. südbayrischen Alpengebirges, 1851. Von Hauer, "Kössener-Schichten," Jahrbuch der k. k. geologischen Reichsanstalt, 1853, p. 733. Escher, "Oberes St. Cassian," Geologische Bemerkungen über Voralberg, 1853. Gümbel, "Gervillien-(Kössener-) Schichten in der Grünten," Geognostische Skizze, 1856. Oppel and Suess, "Kössener-Schichten," 1856, Sitzungsber. Akadem. Wissenschaft. Wien, vol. xxi. p. 535. Oppel, "Kössener-Schichten," 1857, ibid. vol. xxvi. p. 7; "Bone-bed," Juraformation (1856), pp. 16 & 290. Winkler, "Die Schichten der *Avicula contorta* inner- und ausserhalb der Alpen," 1859. Oppel, "Die Zone der *Avicula contorta*," Württemberg naturw. Jahreshefte, 1859, p. 315. Lyell, "Infra-liassic Strata of Austrian Alps," Supplement to the Manual of Geology, 5th edit., 1857. Suess, "Kössener-Schichten," Ueber die Brachiopoden, &c., 1854. Jules Martin, "Infra-Lias" (pars), Paléontologie stratigraphique de l'Infra-Lias du Département de la Côte-d'Or, Mém. Soc. Géol. France, 2e série, vol. vii. 1860.

The *Avicula contorta* beds, as proved by the list of synonyms prefixed to this section, have for thirty years engaged the attention of geologists, who, after much discussion as to their true place in the series, are still divided in opinion as to whether they ought to be considered the upper portion of the Keuper or the basement-beds of the Lias. It is now generally admitted that the *facies* of the fauna of the *Avicula contorta* beds has more affinities with the Kössener-Schichten of the Tyrol and the Upper St. Cassian beds of Germany than with the true Lias; and I shall demonstrate that most of the species of *Radiata*, *Mollusca*, and Fishes found in the *Avicula contorta* beds are special to them, and do not pass into the Lias.

At one time the Upper St. Cassian beds were considered to belong to the Trias, and the Fishes found therein were registered by Agassiz as Triassic; whilst the *Conchifera* were remarked to have many affinities with species found in the Muschelkalk. A better acquaintance with the fauna of the St. Cassian and the Kössen beds has proved, however, that most of the leading species in these formations are found in the *Avicula contorta* beds, and that in fact they all belong to one zone of life which lies upon the confines of the Keuper and the Lias formations, having a common boundary-line in the sandstones and shales below that remarkable stratum the Bone-bed, which has been found to occupy the same relative position in the *Avicula contorta* series of England, France, Luxemburg, Germany, the Tyrol, and the Jura.

In all these countries it contains portions of the same species of Fishes, and probably of Reptiles, under similar fragmentary conditions, forming a true Bone-breccia.

Section at Garden Cliff.—The following section of Garden Cliff on the Severn, near Westbury, affords the best exposition of the *Avicula contorta* beds in Gloucestershire; and as each stratum rises in succession by the river-bank, it can be examined and measured with great exactness. This section differs in many important points from others which have been published by previous observers, as those of De la

Beche and Brodie; but, as I have had the pleasure of examining this section lately in company with my friends Messrs. J. Jones and Lucy, of Gloucester, whose observations entirely agree with my own, I feel more confidence in the accuracy of the details here given, after their having been tested by three different observers.

Section of the Avicula contorta *beds at Garden Cliff near Westbury-on-Severn.*

(The beds are described in descending order.)

No.	Lithology.	ft.	in.	Organic Remains.
1.	The *Ostrea-bed*; a hard, dark-grey, argillaceous Lias limestone; many shells on the surface	0	4	*Ostrea liassica*, Strickl., *Modiola minima*, Sow., *Cardium*, n. sp. (This bed is one of the lowest of the *Ammonites planorbis* series.)
2.	Greyish clay ......from 1 ft. to	2	0	
3.	The *Monotis-bed*; a cream-coloured, argillaceous, fissile limestone ....from 4 in. to	0	8	The Monotis-bed contains *Monotis decussata*, Goldf., in great profusion in the upper laminæ; and in the lower, *Myacites musculoides*, Schl.(?), *Cardium Rhæticum*, Mer., *Modiola minima*, Sow., *Monotis decussata*, and *Ostrea liassica*.
4.	Greyish shaly clay...from 1 ft. to	2	0	
5.	The *Estheria-bed*; a light-grey nodular limestone, in parts shelly; forming a prominent band in the cliff	1	0	The Estheria-bed contains in some part nests of *Estheria minuta*, Bronn. In the shelly portions I have found *Pecten Valoniensis*, Defr.
6.	Dark friable shale; containing many fossiliferous seams: 8 ft. to	10	0	Many small compressed *Conchifera*, which have not been determined.
7.	Dark shaly clay; containing many compressed shells	1	0	*Pullastra*.
8.	Dark shale; containing many seams of compressed shells	4	0	
9.	The *Pecten-bed*; a dark argillaceous limestone	0	2	*Pecten Valoniensis*, Defr., numerous and compressed.
10.	Black shales	6	0	Fossils rare: bodies resembling Coprolites.
11.	The *Bone-bed*; a thin band of greyish calcareo-siliceous rock; containing osseous *débris* and much pyrites. A true bone-breccia	0	1	Bones of Saurians and Fishes, teeth of Reptiles, teeth of Fishes, as *Saurichthys*, *Acrodus*, *Hybodus*, and *Ceratodus*, with many Coprolites.
12.	Black shales	2	0	
13.	Dark-grey micaceous sandstone; ripple-marked on the upper surface; forming a prominent bed in the cliff; large slabs lie on the shore ....9 in. to	1	0	*Avicula contorta*, Portl., *Cardium Rhæticum*, Mer., *Pullastra arenicola*, Strickl., and *Modiola minuta*, Goldf.
14.	Black shale	2	0	
15.	A band of grit resembling No. 13; containing scales and teeth and much pyrites	0	4	Bones, scales, and teeth of Fishes, *Pullastra arenicola*.
16.	Hard black shale	2	0	Bodies resembling Coprolites.
	Grey marls of the Keuper.			

The beds are all conformable, and dip to the S.E. at angles varying from 2° to 4°. The Keuper Marls are well exposed in the Cliff, with

a thickness of above 80 feet. When this section is lit up by the sun's rays, and seen at a distance of two miles, it has a most beautifully picturesque appearance from the varied colouring of its different beds.

Section at Wainlode Cliff.—Wainlode Cliff on the Severn, between Gloucester and Tewkesbury, affords a similar section of the same beds, the details of which have been already published by the late Mr. H. E. Strickland in his paper on the Bristol Bone-bed*, and by the Rev. P. B. Brodie in his work on Fossil Insects†. The following abstract will enable the reader to correlate the strata at Wainlode with those at Garden Cliff.

Section at Wainlode Cliff.

	ft.	in.
1. Thin beds of Lias-limestone, alternating with beds of clays and marls, and having quite near the top a band of hard lias-limestone; the *Ostrea-bed*, with *Ostrea liassica*, Strickl., and *Modiola minima*, Sow.	22	0
2. Hard, greyish, slaty bed, containing scales and teeth of Fishes (*Gyrolepis*, *Hybodus*, and *Saurichthys*)	0	1
3. Dark-coloured slaty clay	1	6
4. The *Pecten-bed*; a dark-coloured, pyritic, calcareous sandstone, containing *Pecten Valoniensis*, Defr., in considerable numbers, *Avicula contorta*, Portl., and two other species of shells	0	4
5. Dark laminated clay	9	0
6. The *Bone-bed*; a dark, hard, pyritic sandstone, containing bones, scales, and teeth of *Gyrolepis*, *Hybodus*, and *Saurichthys*, imbedded in a light-coloured sandstone, in which are abundance of *Pullastra arenicola*, Strickl., and *Avicula contorta*, Portl.	0	3
7. Black shales	2	0
8. Light-greenish marl, breaking into angular fragments	23	0
9. Red marl, with bands of a greenish colour	42	0
[The beds dip very slightly to the south.]		
	100	2

Coombe Hill.—On lowering the road to the canal which passes through the low escarpment formed by the junction of the Lias and Red Marl at Coombe Hill, near Cheltenham, and 3½ miles north-east of Wainlode Hill, the *Avicula contorta* beds were cut through, and a considerable quantity of the Bone-bed was obtained. The late Mr. Dudfield of Tewkesbury made a large collection of specimens of the Bone-bed from this cutting, and the late Mr. H. E. Strickland gave a detailed section in his paper‡ on this subject. Beneath 22 feet of Lias-clays, the following beds were found:—

	ft.	in.	
Dark, impure, pyritic limestone	0	6	With *Pecten Valoniensis* and *Pullastra*.

* Proc. of the Geol. Soc. vol. iii. p. 586.
† Fossil Insects of the Secondary Rocks, p. 58.
‡ Proc. of the Geol. Soc. vol. iii. p. 585.

	ft.	in.	
Black laminated clay	8	0	Apparently unfossiliferous.
Hard, greyish, pyritic limestone	0	2	With bivalve shells, undetermined.
Black laminated clay	1	0	Unfossiliferous.
Greyish sandstone	0	2	With *Pullastra arenicola.*
Black laminated clay	1	6	Unfossiliferous.
Bone-bed	0	1	With teeth of *Saurichthys, Acrodus,* and *Hybodus*; scales of *Gyrolepis*; *Saurian* bones; and Coprolites.
Black laminated clay	3	6	
Greenish, angular, Keuper marls	25	0	

Bushley.—Another intersection of the low escarpment, formed by the junction of the Lias with the Red Marl, on the Ledbury Road near Bushley, exposed a similar section to the preceding. The *Pecten Valoniensis* bed was underlain by 9 feet of black shale, which rested on a light-coloured micaceous sandstone containing *Pullastra arenicola* and *Avicula contorta.*

It is evident from these details that the *Avicula contorta* beds in Gloucestershire and Warwickshire are very similar in their stratigraphical character.

Aust Cliff.—If we proceed from Garden Cliff down the Severn, the next section of the *Avicula contorta* beds is met with at Aust Cliff, so long famous for its Bone-bed and the large number of *Ceratodus* teeth which from time to time have been collected therefrom. My friend Mr. William Sanders, of Bristol, measured this section some years ago, and the results of his observations were published by Sir Henry De la Beche in his valuable memoir on the Geology of the South-west of England*. Buckland and Conybeare† had previously published a section of Aust Cliff in their memoir on the South-western Coal-district of England.

In the upper part of the section we find about 2 feet 6 inches of a grey argillaceous limestone, containing *Ammonites angulatus*, Schlth., *Lima gigantea*, Sow., *Lima antiquata*, Sow., and *Modiola Hillana*, Sow., representing the bottom-beds of the *Lima* series. Below these are nine beds, consisting of grey marls and argillaceous limestones, representing the zone of *Ammonites planorbis*; the lowest limestone-bed of that set contains scales of Fishes, elytra of Insects, with *Modiola* and *Terebratula.*

This rests upon

		ft.	in.	
Zone of *Avicula contorta.*	Black shales	6	0	
	Grey argillaceous limestone	0	8	With Fishes' scales, abundant.
	Black laminated shale	3	0	
	Calcareo-arenaceous bed ...	0	2	With Saurian bones and Fishes' scales.
	Black laminated shale	0	8	
	Bone-bed ....1 in. to	0	8	With Fishes' teeth, Saurian bones, and Coprolites.
Keuper marls.	Pale arenaceous marls ...	1	0	
	Greenish marls	2	0	
	Variegated red marls......	120	0	

* Memoirs of the Geological Survey of Great Britain, vol. i. p. 253.

† Geol. Trans. 2nd series, vol. i. pl. 37.

Pecten Valoniensis is found in blocks on the shore, and likewise slabs of sandstone with *Pullastra arenicola*. The Bone-bed abounds with the teeth of *Ceratodus* and other Fishes; and the vertebræ and other bones of Saurians and Fishes are strewed, together with Coprolites, abundantly throughout this remarkable rock, which here forms a conglomerate composed of rounded portions of an argillo-arenaceous and calcareous rock, with which are mingled the bones, teeth, and coprolites of Reptiles and Fishes.

The Bristol Museum contains a series of fossils from the Aust Bone-bed; but the finest collection of *Ceratodus* teeth from this locality has been made by Mr. Higgins of Birkenhead, who reckons that he has found 140 different forms of the teeth of this singular genus.

Section at Penarth Cliff.—On the opposite side of the Bristol Channel at Penarth Head, near Cardiff, a magnificent section is exposed, showing the Lower Lias and *Avicula contorta* beds resting on the variously coloured marls of the Keuper. The lower half of this cliff may be considered as a roll of the same beds which I have already described as occurring at Garden Cliff, 44 miles higher up the River Severn. At Penarth the relative position of the zone of the *Ammonites Bucklandi*, the zone of *Ammonites planorbis*, and the zone of *Avicula contorta*, with the red and grey marls of the Keuper, are all seen *in situ* in this fine and instructive coast-section.

The upper part of Penarth Head is composed of alternate beds of limestone and shale which represent the zone of *Ammonites Turneri*, with *Pentacrinus tuberculatus*, Mill., *Cardinia ovalis*, Stutch., and *Gryphæa incurva*, Sow. These attain a thickness of from 10 to 15 feet, and overlie the *Lima*-beds or zone of *Ammonites Bucklandi*, which, in like manner, consists of alternate beds of limestone and shales, having a thickness of 50 or 60 feet. They are well seen in the cliff, forming a vertical wall, and may be examined in the quarries behind the church. I collected here *Lima antiqua*, Sow., *Lima gigantea*, Sow., *Lima punctata*, Sow., *Lima pectinoides*, Sow., *Cardinia hybrida*, Stutch., *Unicardium cardioides*, Phil., two or three species of *Pecten*, and a large-ribbed *Lima*. Beneath the *Lima*-series are beds of laminated clay, containing *Ammonites planorbis*, Sow., and alternate beds of marly clay and courses of limestone, with an abundance of *Ostrea liassica*, Strickl., on the surface of some of the slabs. These beds attain a thickness of about 10 feet or more, and are underlain by a bed of stiff clay containing *Ostrea liassica* and *Modiola minima*.

The *Avicula contorta* beds form an important feature in the cliff, consisting, as they do, of blackish shales interposed between the light-coloured marls of the Keuper, below, and the light-coloured limestones and shales of the *A. planorbis* bed above. By measurement I found the thickness of the *Avicula contorta* series to be 18 feet; and I could see them distinctly in the section some miles out in the channel. The uppermost bed consists of 5 or 6 feet of a dark marly clay, with *Myacites* and *Arca*, of undescribed species, which lie in seams; in

the bed beneath the marl is a band of hard calcareous rock, which appears to be very persistent; on its upper surface lie immense numbers of *Pecten Valoniensis*, Defr., closely compressed together, but in a bad state of preservation. With these are associated a fine-ribbed *Anomya*, and other shells in a fragmentary state. Beneath this *Pecten*-band lie many feet of dark shales, and then another stony band with *Pecten Valoniensis*, underlain by shales and layers of ripple-marked micaceous sandstone, with *Avicula contorta*, Portl., and *Pullustra arenicola*, Strickl. The Bone-bed occurs likewise in this section, although I failed to find it *in situ*, from the weather having been unfavourable during the previous day. Between the sandstone and the Keuper is a black shale 2 feet thick. The uppermost bed of the Keuper, on which the shales repose, is a very hard rock. The greenish-grey marls of the Keuper, with a few purple-coloured bands, measure about 30 feet. Beneath these is a band of pure white gypsum, succeeded by other variegated, red, and greenish marls, of which 30 feet or more is seen.

Section at Uphill Cutting, near Weston-super-Mare, on the Bristol and Exeter Railway.—The *Avicula contorta* beds in Somersetshire are exposed by a railway-cutting at Uphill near Weston-super-Mare, and on the coast at Watchet. At the former locality I obtained a section of the Lias resting conformably on the marls of the Keuper; but it has been suddenly upheaved and inclined to a high angle by the intrusion of Carboniferous Limestone, which has been thrust upwards by a mass of igneous rock seen *in situ* near the level of the railway. The disturbance has been quite local, as the red marl is only slightly disturbed at a short distance from the Carboniferous Limestone.

			ft.	in.
	a.	Alternate beds of light-coloured Lias limestone and shales, inclined at an angle of 40°, much fractured and disturbed	10	0
Zone of *Ammonites planorbis.*	*b.*	Dark-greyish laminated shales, interstratified with thin bands of limestone; between the laminæ of the shales are found *Ammonites planorbis*, Sow., compressed, and having the shell white	14	0
	c.	Band of Lias limestone	0	6
	d.	Dark shale, with *Ostrea liassica*, Strickl.	3	6
	e.	Band of Lias limestone	0	4
	f.	Dark shale, with *Ostrea liassica*, Strickl.	3	0
	g.	Beneath the preceding bed are from twelve to fourteen beds of limestone and shales or marl (a bed of limestone and a bed of marl alternating). *Ostrea liassica* and *Modiola minima* are found sparingly in the beds	12	0

			ft.	in.
Zone of *Avicula contorta*.	*h.*	Thin band of dark grit, containing scales and teeth of Fishes	0	$1\frac{1}{2}$
	i.	Dark-grey shaly marl	4	6
	j.	*Upper Pecten-bed*; a dingy-coloured pyritic limestone, containing *Pecten Valoniensis*, Defr., *Cardium Rhæticum*, Mer., and other shells undetermined..	0	2
	k.	Grey marl	0	2
	l.	Band of limestone with Pectens and gypsum	0	2
	m.	Dark marl	4	0
	n.	*Lower Pecten-bed*; a dark pyritic limestone, containing *Pecten Valoniensis*, Defr., *Avicula contorta*, Portl., and *Anomya*, sp.	0	6
	o.	Dark marls	3	0
	p.	Laminated shale	0	3
	q.	Dark marl	1	9
	r.	Stony band or impure limestone	0	3
	s.	*Coprolite-bed* (*Bone-bed*); teeth, scales, and coprolites....................	0	2
	t.	Dark shaly marl	3	6
	u.	Band of stone	0	8
	w.	Dark indurated marl	2	0
	x.	Band of stone	0	6
	y.	Dark indurated marl, resting on a pebbly conglomerate	3	6

Green Keuper marl.

[I am indebted to my friend Mr. Day, of Weston-super-Mare, for assisting me to complete the details of the lower beds of the above section.]

In this cutting the uppermost portion of the grey marls of the Keuper are overlain by a thin bed of conglomerate, formed of small round quartz-pebbles (*y*); on this the first bed of black shale rests. The Bone-bed is now with difficulty found *in situ*; portions of it, however, are among the spoil on the bank. In blocks of sandstone I found the teeth of *Saurichthys*, *Hybodus*, *Gyrolepis*, and fragments of bones and coprolites. This thin band of dentiferous sandstone is interstratified with the black shales.

The Lower Pecten-bed is a dark, slate-coloured, pyritic, semi-indurated shale, containing several compressed *Conchifera*. The only species that I could determine was *Pecten Valoniensis*, Defr. The dark shales (*m*) above this bed contain few, if any, fossils; but impressions of shells are seen sometimes between the laminæ.

The Upper Pecten-bed (*j*) consists of a band of hard, greyish, argillaceous limestone, from 8 to 10 inches in thickness; it is traversed by veins of crystallized carbonate of lime, and contains many fossil shells. I collected from two or three blocks *Pecten Valoniensis*, Defr., *Cardium Rhæticum*, Mer., *Modiola*, *Myacites*, *Avicula contorta*, Portl., and *Anomya*. As small blocks of this bed can now only be

obtained with difficulty, the list is consequently very limited; some of those, however, which I broke all contained fossils in moderate numbers. Could this bed be worked, I have no doubt other species might easily be added to our list. The Upper Pecten-bed is overlain by about 5 feet of dark laminated shales (*i*), in which I found no fossils.

The greyish limestone and shales (*g* to *a*), containing *Modiola minima* and *Ostrea liassica,* which succeed the *Avicula contorta* beds, attain a thickness of from 18 to 20 feet. I regard this series as the equivalent of the Lower Saurian beds at Street. These beds will be described in detail under that section.

The *Am. planorbis* bed (*b*) is represented by dark-greyish laminated shales containing compressed shells of *Ammonites planorbis,* Sow., which are inclined at an angle of 45° high up in the cutting, and have been very much disturbed by the upraised limestone.

The alternate beds of light-coloured limestone and shales (*a*), highly inclined and much fractured, appertain to the zone of *Ammonites Bucklandi,* as in them I found portions of *Lima gigantea,* Sow. These beds very much resemble similar strata of the *A. Bucklandi* series seen *in situ* at Up-Lyme, and which will be described in the sequel.

Watchet.—The *Avicula contorta* beds are exposed in a coast-section at Watchet, where the zone of *Am. planorbis* has been long known from its having yielded shales containing the original specimens of *Ammonites planorbis* and *Am. Johnstoni,* first figured by Sowerby in the 'Mineral Conchology.' The nacreous layer of the shells is beautifully preserved in these Ammonites from Watchet.

The Bone-bed here consists of a hard, bluish-grey, sandy limestone, about an inch in thickness, containing fragments of bone, with teeth and scales of Fishes. In the bands of sandstone small shells (*Pullastra arenicola*) are found in the state of moulds.

Beer-Crocomb.—My friend the Rev. P. B. Brodie informs me (September 25, 1860) that at Beer-Crocomb, about five miles from Ilminster, in Somersetshire, he found several years ago the Insect-limestone, which contained wings of *Orthophlebia,* elytra of *Coleoptera,* a few small *Ammonites, Aptychus,* &c. There were several thin beds of limestone divided by layers of clay, but not so thick as those in Warwickshire. Near the quarries, on the banks of the Bridgewater Canal, the Red marl with gypsum is seen, which was dug out in forming the tunnel some years previous to 1847. On the spoil-banks were blocks of a light-coloured limestone, which lithologically resembles the "Cypris-bed," between the Insect-limestone and the Bone-bed, in Gloucestershire and Warwickshire. It contained a considerable number of small univalve and bivalve shells in good preservation. The exact position of this fossiliferous band could not be seen *in situ*; but it probably lies beneath the Insect-bed, between that band and the Red marl. Mr. Brodie has kindly sent me the specimens which he collected at Beer-Crocomb; and I have found them to resemble the fossils that I collected from the same stratum at Uphill. The Beer-Crocomb shells are in fine preservation: besides several forms unknown to me, I have found the following species:—

Natica. (A very small shell.)	Anomya. Small.
Gervillia præcursor, *Quenst.*	Cardinia. Small.
Lima præcursor, *Quenst.*	Cardium Rhæticum, *Mer.*
Neoschizodus (Trigonia) posterus (?), *Quenst.*	Cardium. (Resembling the Westbury shell.)
Avicula contorta, *Portl.*	Leda.
Myacites musculoides (?), *Schl.* (The same form as at Westbury.)	Cypricardia. (Small.)
	Mytilus minutus, *Goldf.*

Quenstedt's specimens (Der Jura, Tabl. i. pp. 27 & 28) were collected from beds which he describes as "Die Vorläufer von Nürtingen," which lie below the Bone-bed; they are consequently the equivalent of the stratum now under consideration.

Culverhole.—The *Avicula contorta* beds are represented at Culverhole, near Axmouth, by a series of black shales, interstratified with limestone-bands, and having the Bone-bed at their base, in the following order, from above downwards:—

No.		ft.	in.	No.		ft.	in.
1.	Black shale	3	0	5.	Black shale	1	6
2.	Limestone	0	10	6.	Limestone	0	10
3.	Black shale	5	0	7.	Black shale	7	0
4.	Limestone	0	10	8.	Bone-bed	0	2

My notes on the contents of the limestone-bands and shales are too imperfect for publication. The Bone-bed, however, contains Coprolites and the teeth and scales of Fishes; of these I have seen remains of *Gyrolepis*, teeth of *Hybodus* and *Saurichthys*, as well as bones of Saurians in masses of this bone-breccia.

Staffordshire.—The sandstone of the Bone-bed has been found, by Mr. H. Howell, of the Geological Survey, at Abbot's Park, near Abbots Bromley, Staffordshire, at the base of an outlier of the Lower Lias. In a section which is exposed in the road at Buttermilk Hill, on the northern escarpment of this outlier, Mr. Howell found some beds of impure limestone, above which is a thin bed of micaceous sandstone containing *Pullastra arenicola*, Strickl., and what appear to be *Estheriæ,* all of which are in moulds and casts.

This bed is about one foot thick; and there can be no doubt that it is the representative of the Bone-bed of the Lias, for it occupies the same position, and is in every respect similar to the bed of sandstone which occurs at the base of that formation near Tewkesbury*.

Warwickshire.—The *Avicula contorta* beds are exposed in several localities in Warwickshire, as at Wotton Park near Alcester, and at Church Lench near Evesham; sections of these beds are seen likewise in the Stratford-on-Avon Railway near that town, and at the western extremity of the Harbury Cutting of the Great Western Railway. They have also been exposed near Binton; and lately their thickness and contents have been ascertained by a sinking made at Messrs. Greaves and Kershaw's quarry at Wilmcote, of which the following detailed section† affords all the particulars, at the same

* See Mem. Geol. Survey: Explanation of Section, No. 2, across the New Red Sandstone, Horizontal Section, Sheet 57, p. 6, 1859.

† In introducing this valuable and instructive section, it may not be out of

time showing the relation of these beds to the zone of *Ammonites planorbis,* which overlies them.

Section of Messrs. Greaves and Kershaw's Quarry at Wilmcote, near Stratford-on-Avon.

	No.	Lithology.	Thickness. ft.	in.	Organic Remains; and the Local Names of the Beds.
Ammonites planorbis Beds.	1.	Yellowish clay	2	6	
	2.	Light-coloured limestone	0	9	"Top Blocks." (*Dapedius* ?)
	3.	Dark laminated shales	1	8	*Ammonites planorbis,* Sow.
	4.	Light-coloured limestone	0	8	"Bottom Blocks."
	5.	Dark finely laminated shales	1	6	*Ammonites planorbis,* Sow.
	6.	Greyish limestone	0	4	"Fine course."
	7.	Dark finely laminated shale	1	0	*Ammonites planorbis,* Sow.
	8.	Greyish limestone	0	4	"Mawms."
	9.	Dark laminated shale	1	0	
	10.	Greyish limestone	0	4	"Top Whites."
	11.	Dark laminated shale	1	0	
	12.	Greyish limestone	0	4	"Bottom Whites."
	13.	Dark laminated clay	0	8	
	14.	Greyish limestone, irregular in thickness	0	2	"Livery Beds."
	15.	Dark laminated clay	0	9	
	16.	Grey limestone	0	5	"Ribs."
	17.	Dark laminated clay	0	7	
	18.	Greyish limestone	0	3	"Hoggs."
	19.	Dark laminated clay	4	2	
	20.	Fragmentary shelly bed	0	3	"Grizzle-bed."
Ostrea liassica and Saurian Beds.	21.	Dark, hard, stony clay	0	7	"Ruskins." *Plesiosaurus megacephalus,* Stutchb. (Warwick Museum.)
	22.	Dark-blue limestone and clay	0	9	"Blue Blocks" or "Fire-stone blocks."
	23.	Dark clay, laminated	1	0	
	24.	Dark greyish limestone	0	$4\frac{1}{2}$	"Pendle and Jackets." *Ostrea liassica, Modiola minima,* and *Cardium.*
	25.	Hard crystalline limestone	1	2	Fire-stone, top bed.
	26.	Hard crystalline limestone			Fire-stone, middle bed.
	27.	Hard crystalline limestone			Fire-stone, bottom bed.
					Bottom of the quarry: shaft sunk below this.
	28.	Hard, dark, slaty shale	1	0	
	29.	Hard shelly limestone	0	1	"The Guinea-bed."
	30.	Green clunchy shale	3	0	

place to state the economic uses of these valuable beds, as few persons appear to be aware of the many purposes to which they are applied. The upper beds of limestone, which are usually of a light colour, are polished, cut into squares, and employed for paving; the grey limestones are prepared in the same manner, and likewise used for paving; hence they are called in Warwickshire the "paving-beds." In flooring halls, the light and grey squares of these beds, laid diagonally, produce a very good effect and form a durable pavement. The shales are burned in kilns, and ground between cylinders to a fine powder; by this means a first-rate cement is prepared, which is largely used in the Midland Counties, and is sold at the works for one shilling a bushel, or at the rate of four shillings per barrel.

	No.	Lithology.	Thickness. ft.	in.	Organic Remains; and the Local Names of the Beds.
Westbury Beds*.	31.	Fine-grained greenish marl ...	0	3	Estheria-bed. *Estheria minuta*, in clusters.
	32.	Blackish shales, not laminated	12	6	
	33.	Close, laminated, micaceous, greenish-black shale	1	0	
	34.	Closely laminated shale	0	6	
	35.	Laminated shale	1	6	Upper Pullastra-bed. *Avicula contorta*, *Pullastra arenicola*, and *Cardium*.
	36.	Hard, close shale, not laminated	2	6	
	37.	Dark clay and shale	0	6	
	38.	Strong laminated clay, with septaria	1	3	Pecten-bed. *Pecten Valoniensis*.
	39.	Clay, with shells	1	8	
	40.	Black, hard, laminated clay ...	4	0	
	41.	Pyritic stone, with shells	0	1	Lower Pullastra-bed.
	42.	Black clunchy clay	0	8	
	43.	Light, soft, brown clay.			

The Bone-bed has been found at Temple Grafton; but it is represented in some of the other sections by a pyritic sandstone, in which no true bone-breccia has been found.

Fossils of the Avicula contorta *Zone*.—The Bone-bed has yielded of Reptiles—*Ichthyosaurus*; femur at Garden Cliff; vertebræ at Frethern, Aust, and Wainlode. *Plesiosaurus*; vertebræ at Garden Cliff and Aust.

Besides these determinable bones, there are a great number of Saurian bones which cannot be named, on account of their fragmentary condition.

In 1841 Sir Philip Egerton read a paper before the Geological Society on the occurrence of Triassic Fishes in British strata, and enumerated several species of Placoids and Ganoids, obtained from the Bone-beds of Aust and Axmouth, which, in conjunction with M. Agassiz, he considered as Triassic species. In his conclusions from this Ichthyologic evidence, Sir Philip stated that "he feels justified in advancing from the facts adduced in this communication, that the beds in question (the Bone-beds) hitherto considered as belonging to the Lias must be removed from that formation, inasmuch as they present a series of Fishes not only specifically distinct from those of the Lias, but possessing in the ganoid genera the heterocerque tail, an organism confined to the Fishes which existed anterior to the Lias†."

In the following Table I have given lists of the species of Fishes hitherto found in the Bone-beds of England, and I have added from Bronn's 'Index Palæontologicus,' the rock and locality where the same species are said to occur on the Continent.

* Lithology and thickness obtained by sinking.
† Proc. Geol. Soc. vol. iii. p. 409 (1841).

Table showing the localities of the Fishes of the Bone-bed of England and the Continent.

Genus and species.	Bone-bed at Garden Cliff.	Bone-bed at Coombe Hill.	Bone-bed at Aust Passage.	Bone-bed at Axmouth.	St. Cassian beds.	Knochen-breccie of Württemberg.
Acrodus minimus, *Ag.*	*	*	*	*	...	*
—— acutus, *Ag.*	...	...	*	...	...	*
Nemacanthus filifer, *Ag.*	*	...	*	...	...	*
—— monilifer, *Ag.*	*	*	*	...	...	*
Hybodus minor, *Ag.*	*	*	*	*		
—— læviusculus, *Ag.*	...	...	*			
—— plicatilis, *Ag.*	...	...	*	*	*	
—— raricostatus, *Ag.*	...	...	*			
Gyrolepis Albertii, *Ag.*	*	*	*	*	*	*
—— tenuistriatus, *Ag.*	*	*	*	*	...	*
Ceratodus altus, *Ag.*	...	...	*			
—— emarginatus, *Ag.*	...	...	*			
—— gibbus, *Ag.*	...	...	*			
—— latissimus, *Ag.*	...	...	*			
—— obtusus, *Ag.*	...	...	*			
—— trapezoides, *Ag.*	...	...	*	...	...	*
Saurichthys apicalis, *Ag.*	*	*	*	*	*	*
—— longidens, *Ag.*	...	...	*	...	...	*

[Some of the species of Fish are also represented by teeth and scales in other beds of the *Avicula contorta* series, as at Wainlode.]

The Molluscan remains obtained from the *Avicula contorta* series, including the Bone-bed, are:—

Pullastra arenicola, *Strickland.*
Cardium Rhæticum, *Merian.*
Arca, n. sp.
Anomya, n. sp.
Modiola minima, *Sow.*
Modiola minuta, *Goldf.*
Myacites musculoides (?), *Schlotheim.*
Myacites, n. sp.
Monotis decussata, *Goldfuss.*
Avicula contorta, *Portlock.*
Pecten Valoniensis, *Defr.*
Ostrea liassica, *Strickland.*

The little bivalved Crustacean *Estheria minuta*, Bronn, and Coprolites of Fishes and Reptiles, complete the list of the organic remains of this zone.

Equivalent of the Bone-bed in the North of Ireland.—General Portlock* found in the North of Ireland, at Lisnagrib and Derrymore, "alternating beds of red and variegated marl, and of red and whitish sandstones, all more or less, but most of them highly, calcareous," of which he says—

"Towards the summit the light-coloured marly and highly calcareous grit .... prevails, and is succeeded by shales and calcareous grits, which form the transition-member between the New Red Sandstone and the Lias, and therefore, in part at least, correspond, as their fossils do, to the Muschelkalk." And again, "Passing upwards from the sandstone, greyish and partly indurated marls

* Report on the Geology of Londonderry, &c. pp. 105 & 107 (1843).

or clays are met with, which form a connecting link between the New Red Sandstone and the Oolitic systems. These are about 17 feet thick. To them succeed alternating beds of dark shale and calcareous grit.

1. "Compact blackish even shale, or clay, the bottom of which is not seen.

2. Seam of calcareous grit, about half an inch thick.

3. Black shale, nine inches.

4. Seam of calcareous grit, about half an inch thick, but variable; with impressions of bivalves on one side, and on the other the teeth and scales of Fishes, viz. *Saurichthys apicalis*, *Gyrolepis Albertii*, *Gyrolepis tenuistriatus*, and *Acrodus minimus* (Muschelkalk fossils).

5. Black shale, seven inches.

6. Calcareous gritty shale, in some parts a calcareous grit, with Bivalves on the faces of lamination; five inches.

7. Black shale with *Avicula contorta* (n. s.) and impressions of *Cardium striatulum*." [*C. Rhæticum*, Mer.]

The correlation of these strata with those at Garden Cliff and elsewhere does not admit of the shadow of a doubt.

§ III. The Lower Lias.

1. The Zone of Ammonites planorbis.

Synonyms.—"White Lias," William Smith, Memoir to the Map, p. 47, 1815. "White Lias," De la Beche, Geol. Trans. 2nd series, vol. ii. p. 26. "Saurian Beds," Murchison's Geology of Cheltenham, 2nd ed., by Buckman and Strickland, p. 49, 1845. "Psilonotenbank," Quenstedt, Der Jura, Table, p. 293, 1857. "Die Schichten des Ammonites planorbis," Oppel, Juraformation, p. 24, 1856.

This division of the Lower Lias is well developed in the South of England. In general it consists of a series of thin, greyish or bluish, argillaceous limestones, with alternating beds of laminated shale; or sometimes the entire series forms a thick-bedded, argillaceous, cream-coloured limestone, called "the White Lias" by William Smith. In the upper half of this group of beds *Ammonites planorbis*, Sow., is found in great numbers, compressed in the shales, with its white shell more or less preserved; in the lower portion of the series *Ostrea liassica*, Strickl.*, appears in great numbers; and beneath these strata are three or four beds of hard limestones (or "Fire-stones"), in which the finest skeletons of *Enaliosauria* have been discovered. As this distinction, by means of *Am. planorbis*, *Ostrea liassica*, and Saurians, is a practical and useful one in the investiga-

* *Ostrea liassica*, Strickland, is a very characteristic shell of the lowest Lias beds. It resembles *Ostrea irregularis*, Münster (Goldfuss, Petr. Germ. pl. 7–9. fig. 5) and *Ostrea rugata*, Quenstedt (Jura, pl. 3. fig. 17). Dunker in the 'Palæontographica' (pl. 6. fig. 27) has figured a small Oyster from the Lias of Halberstadt (*Ostrea sublamellosa*, Dunker), which appears to be identical with our species. These small, thin, rugose Oysters are found in great abundance in the lowest beds of the Lower Lias in England and Germany. They are probably only varieties of one species, which had a wide geographical distribution in the seas which deposited the basement-beds of the Lias.

tion of this zone of life, I shall adhere to it on the present occasion,—premising, however, that *Ammonites* are very rare in the lower beds, although abundant in the upper; and that *Ostreæ* are abundant below, but rare above, whilst Saurian remains are found throughout the entire series.

Somersetshire.—The best sections of the zone of *Ammonites planorbis* are those afforded by the extensive quarries at Street, in Somerset, and at Binton and Wilmcote, in Warwickshire. I purpose to give a detailed description of the most typical section in each county. In both, the strata are nearly horizontal and undisturbed, and therefore admit of accurate measurement.

The following section of Mr. Cree's quarry at Street I have compared with the sections afforded by the quarries of Messrs. Seymour, Underwood, and Talbot in the same parish; and find that the variation in all these sections is so inconsiderable that any one may be said to represent the others, both as regards the sequence of the beds and the fossils they contain.

Section of the Zone of Ammonites planorbis *at Street, Somerset.*

No.	Lithology.	ft.	in.	Organic Remains; and the Local Names of Beds.
1.	Light-coloured marly clay ...	3	0	"Top bed." Saurian bones and *Ammonites planorbis*.
2.	Light-coloured Lias limestone	0	9	*Ammonites planorbis* in moulds.
3.	Yellowish laminated shale, splitting up into thin layers	3	0	*Ichthyosaurus intermedius*, *Ammonites planorbis*, *Lima punctata*, and *Isastræa Murchisoni*.
4.	Light-coloured shaly limestone	0	4	*Ammonites planorbis*, compressed.
5.	Hard grey limestone	0	7	"Building-stone." *Ammonites planorbis*, on the top of the bed, *Lima punctata* and *Lima gigantea*.
6.	Dark-grey shale	0	3	*Ammonites planorbis*, and muricated spines of *Cidaris*.
7.	Dark-grey limestone	0	6	"Corn-sized building-stone." Spines of *Cidaris* and bones of *Ichthyosaurus tenuirostris*.
8.	Dark laminated shale	0	4	*Ostrea liassica*.
9.	Dark-grey limestone	0	5	"Five-inch building-stone." *Ostrea liassica*.
10.	Dark shale	0	3	*Ostrea liassica*.
11.	Dark-grey limestone	0	6	"Six-inch building-stone." *Cardinia crassiuscula*, *Lima punctata*, and *Ostrea liassica*.
12.	Dark shale	0	6	
13.	Greyish hard limestone, consisting of two 4-inch beds ...	0	8	"The White stone." Best paving-bed. Fossils rare; *Ostrea liassica* and *Modiola minima*.
14.	Hard dark marl	0	9	"Saurian bed." Many Saurians have been obtained here. *Ichthyosaurus intermedius* and *Plesiosaurus Hawkinsii* (British Museum). Jaws of Saurians and Fishes.
15.	Greyish fine-grained limestone	0	3	"The Cream-bed." Fine-grained paving-stone. *Ostrea* and *Modiola*.
16.	Brownish limestone...........	0	4	"Red Liver." Paving-stone. Few fossils.

No.	Lithology.	ft.	in.	Organic Remains; and the Local Names of Beds.
17.	Dark-coloured limestone	0	4	The "Black stone," used for large paving-slabs; some of them 10 ft. by 5 ft. *Modiola minima*, *Ostrea liassica*, *Myacites*, and *Rhynchonella variabilis*.
18.	Dark-blue shale	0	2	*Ostrea liassica* and *Modiola minima*.
19.	Hard greyish limestone	0	6	"Six-inch building-stone." *Ceromya*, *Modiola minima*, and *Ostrea liassica*.
20.	Soft bluish shale	0	2	
21.	Greyish-blue limestone	0	4	"Four-inch building-stone." Fossils as in No. 19.
22.	Dark-grey laminated shale	0	4	*Ichthyosaurus intermedius* and *I. tenuirostris*.
23.	Hard blue limestone	1	0	"The Blue Clog," or "One-foot building-stone," used for steps. *Ceromya*, *Ostrea*, *Modiola*, and *Rhynchonella*.
24.	Grey laminated shale	1	3	Saurians abundant; *Ichthyosaurus intermedius* and *I. tenuirostris*, now in Mr. Seymour's possession. *Pholidophorus leptocephalus*, Agass.
25.	Greyish limestone	1	0	"Grey Clog." A valuable building-stone, and used for steps, troughs, &c. *Modiola minima*.
26.	Dark shale	0	2	
27.	Thin-bedded limestone	0	3	"Three-inch blue bed." Fish-remains, *Modiola minima*, and *Otopteris acuminata*, L. & H.
28.	Thick blue limestone	0	5	
29.	Hard fine-grained limestone	0	4	"Fire-stone."
30.	Hard, grey, fine-grained limestone	0	4	*Plesiosaurus Etheridgii*. (In the Jermyn Street Museum; and another is now in Street from this bed.)
31.	Hard grey limestone, forming the bottom bed	1	0	"Fire-stone, bottom bed." *Plesiosaurus Hawkinsii*. [The large *Ples. megacephalus*, Stutch., now in the Bristol Institution, was obtained from the lower beds near Street.]

The Saurian beds near Langport have likewise yielded Reptilian remains. I have obtained two fine specimens of *Ichthyosaurus intermedius* and an imperfect specimen of *I. tenuirostris* from this locality, which are now in the collections of private friends. In connexion with these Saurian beds of Somerset, it is important to note that the oldest *Enaliosauria* of the Lias are *Plesiosauri*, for *Plesiosaurus Hawkinsii*, Owen, and *Pl. Etheridgii*, Huxley, were both exhumed from the 4-inch firestone, forming the bottom bed of Mr. Cree's quarry at Street. The remarkable *Plesiosaurus megacephalus*, Stutch., now in the Bristol Museum, was found likewise in the firestones of a quarry near Street Foss; and it will be shown in my section of the correlative beds of this zone at Wilmcote, in Warwickshire, that the fine skeleton of *Plesiosaurus megacephalus* contained in the Warwick Museum was exhumed from the "firestones" of that locality,—beds which are the precise equivalents of the "firestones" of Street.

The small number of *Conchifera* hitherto found in these beds is very remarkable. *Ostrea liassica*, Strickl., *O. irregularis*, Quenst.,

Modiola minima, Sow., *M. psilonoti*, Quenst., *Gervillia*, n. sp., *Anomya*, n. sp., *Myacites*, n. sp., *Arca*, n. sp., and *Cardium*, n. sp., are the only species that I have as yet collected from the firestone-beds.

This section likewise settles a point which has been often discussed, namely, what is the age of the Saurian beds of Somerset? It has been generally supposed that they belonged to the same horizon as the lower Saurian beds at Lyme Regis; but this is a mistake, inasmuch as the Saurian beds at Street belong to the zone of *Ammonites planorbis*, most of the reptiles having been contemporaries with that Cephalopod. I am aware that this conclusion is somewhat in opposition to the generally received opinion upon the subject; but there cannot be a doubt of its truth, as it admits of the clearest demonstration. The Saurians of Lyme Regis, on the contrary, are for the most part found in beds above the zone of *Ammonites Bucklandi*, as we shall learn when I describe the fauna of that zone (see page 402).

Worcestershire and Gloucestershire.—The *Am. planorbis*, *Ostrea*, and lower Saurian beds, so well developed at Street, are likewise found in different parts of Worcestershire and Gloucestershire, where they present the same stratigraphical relations, and yield the same organic remains.

The neighbourhood of Tewkesbury affords several good exposures of the infra-ammonite beds. I have obtained *Ichthyosaurus tenuirostris*, Conyb., and *Ichthyosaurus intermedius*, Conyb., from a bed of light-coloured Lias at Haselgrove near "the Folly;" and the late Mr. Dudfield, of Tewkesbury, collected several very fine skeletons of *Ichthyosaurus tenuirostris*, Conyb., *I. intermedius*, Conyb., and *I. communis* (?), Conyb., with bones of *Plesiosaurus Hawkinsii*, at Brockeridge Common, and from similar beds at other localities around Tewkesbury; and I possess several vertebræ of *Plesiosaurus rugosus*, Owen, which were obtained from a bed of White Lias at Woolridge near Hartpury.

The junction of the Lower Lias with the red marls of the Keuper in the Vale of Gloucester is, in general, indicated by a low escarpment, which faces the west. At Brockeridge and Defford Commons this natural boundary is exceedingly well marked, and between these two localities there are several quarries which expose to a greater or less extent the beds now under consideration. The presence of *Ammonites planorbis* in the upper strata of several of these sections has enabled me to correlate the beds beneath with the corresponding strata at Street, in Somerset, and at Binton, Grafton, and Wilmcote, in Warwickshire.

Section of the Ammonites planorbis beds, Ostrea beds, *and* Lower Saurian beds *at Brockeridge and Defford Commons.*

Zones.	Strata and Organic Contents.	Brockeridge. ft.	Brockeridge. in.	Strensham. ft.	Strensham. in.
Ammonites planorbis Beds.	1. Light-coloured clay	3	0	3	0
	2. White laminated limestone. "First rub," Brockeridge; "Chance rub," Strensham	0	4	0	4
	3. Brown laminated clay, with compressed white shells of *Ammonites planorbis*	3	0	2	0
	4. Blue argillaceous limestone } "Double rub," Brockeridge; "Double nurf," Strensham.	0	3	0	2
	5. Brown shaly clay }	0	2	0	2
	6. Blue limestone }	0	3	0	2
Ostrea and Lower Saurian Beds.	7. Dark clay, with Saurian remains. "Yard clay"	3	0	3	0
	8. Hard blue limestone. *Ostrea liassica.* On the surface of the rock this bed is called "Red nurf" at Brockeridge, "Kings nurf" at Strensham	1	0	0	3
	9. Dark clay. The second bed of "Yard clay" at Strensham	1	6	3	0
	10. Blue limestone. The "Queen's nurf," Strensham	0	3	0	3
	11. Blue clay	0	0	0	3
	12. Hard blue limestone, with *Modiola minima*	0	0	0	6
	13. Paving-stone, separated by an inch-band of clay	0	0	0	4
	14. Dark shale. Vertebræ of *Ichthyosaurus*, test and spines of *Cidaris Edwardsii*, *Hemipedina*, sp., and Fishes' scales	0	0	0	6
	15. Hard blue limestone, in square blocks. "Brick-bed."	0	0	0	5
	16. Dark shale	0	0	0	3
	17. Insect-limestone; a hard argillaceous limestone, containing the elytra and other remains of Insects	0	0	0	6
	18. Blue shale	0	0	1	3
	19. Light-blue limestone, with *Cardinia*, sp., *Arca*, sp., and *Astarte*, sp.	0	0	0	4

I have placed the above sections together for the purpose of comparison: they were first made by my friend the Rev. P. B. Brodie, and have been subsequently examined by myself with similar results. These sections show the uniformity which prevails in the lower Saurian beds of Gloucestershire and Worcestershire, and how much they resemble their correlative strata at Street.

The late Mr. James Dudfield, of Tewkesbury, obtained from the infra-ammonite Lias beds at Brockeridge enumerated in the preceding sections, and from other strata occupying the same horizon in the vicinity of that town, a very fine series of Saurian remains, which were all sold and dispersed in June 1843. From my notes of that collection, I find there was a specimen of *Ichthyosaurus intermedius*, about 8 feet in length; the two fore-paddles and a portion of the scapular arch were tolerably complete; and there were upwards of 100 vertebræ and ribs nearly all in place. *I. tenuirostris*; 4 feet in length; the skulls, jaws, and teeth well preserved, the vertebral column tolerably complete; and likewise one fore-paddle. *I. communis*; very fine paddles. *I. platyodon*; large skull with orbital

plates in position. *Plesiosaurus Hawkinsii*; the vertebral column, ribs, and humeri; and fifty vertebræ in position.

The *Ostrea* and lower Saurian beds at Binton, Brockeridge, and Street are overlaid by clays and laminated shales, containing *Ammonites planorbis*. As these beds form a most important horizon in the Lias-formation, and have a wide geographical distribution in England, France, and Germany, they require to be defined with accuracy, especially as some authors are of opinion that the true Lias commences with this zone of life.

The relation of the *Am. planorbis* shales to the Saurian beds below is extremely well exposed in the Railway-cutting at Uphill, in the quarries at Street, in the Binton and Wilmcote quarries in Warwickshire, at Brockeridge Common in Gloucestershire, and at Strensham, Worcestershire, and to the *Am. Bucklandi* or *Lima* beds above in the sections at Saltford near Bristol, Penarth Head near Cardiff, and Pinhay Bay near Lyme Regis.

The following section of the beds at Binton was made by Mr. Robt. Tomes, of Welford Hill, near Stratford-on-Avon, from a quarry now abandoned. A similar exposition, however, is seen in the quarry worked near the former, and the various beds of which I examined with Messrs. Tomes and Kershaw.

Section of the Zones of Ammonites planorbis *and* Avicula contorta, *at Binton, Warwickshire.*

No.	Lithology.	Thickness. ft.	in.	Organic Remains; and Local Names of the Beds.
1.	Light-coloured limestone......	0	6	"Top rock" or "Whites."
2.	Light-coloured clay	2	6	
3.	Argillaceous limestone.........	0	3	"Top Liveries." *Ichthyosaurus*; on the upper surface Insects.
4.	Light-coloured clay.............	7	0	
5.	Argillaceous limestone.........	0	3½	"Top Liveries" (lower). Insects; *Ammonites Johnstoni*, Sow.
6.	Clay	1	1	
7.	Greyish limestone	0	6	"Extra rock." "Thick paving-bed." No fossils.
8.	Clay	0	3½	
9.	Greyish limestone. Thin and irregular when covered by the preceding ....2 in. to	0	3	"Quarters."
10.	Clay	0	8½	
11.	Greyish limestone. A constant bed........	0	3½	"Ribs." Insects.
12.	Clay	0	5½	
13.	Limestone........................	0	3	"Paving-stone." A few Insects and *Pholidophorus Stricklandi*, Ag.
14.	Clay	0	10½	
15.	Limestone........................	0	3¼	"Bottom rock." More Insects here than in all the other beds collectively.
16.	Clay	0	8	
17.	Limestone .... 3 in. to	0	6	"Hoggs." *Tetragonolepis angulifer*, Ag. (Warwick Mus.)
18.	Strong hard clay	0	3½	
19.	Argillaceous limestone; imperfect stone	0	3	"Ruskin." No fossils in this quarry.

No.	Lithology.	Thickness. ft.	in.	Organic Remains; and Local Names of the Beds.
20.	Laminated clay	1	6	
21.	Fragmentary shelly limestone	0	1½	"Grizzle bed." Saurian bones, Fishes' teeth and scales, *Ammonites planorbis*, *Lima punctata*, *Cardium*, and *Ostrea liassica*; spines of *Cidaris* and other *Echinidæ* abundant.
22.	Stony shale.			
23.	Hard limestone	0	6	"Blue stone" or "Blocks." *Myacites* and elytra of *Coleoptera*.
24.	Hard clay	1	3	
25.	Limestone	0	3½	"Grave-stone rock." *Ichthyosaurus* and *Otopteris acuminata*, L. & H.
26.	Clay. Thin hard plates of stone lie in this clay	0	11	
27.	Limestone, underlain by clay. (The clay frequently wanting.)	0	0½	
28.	Limestone; inconstant	0	6	"Gummerals." *Ostrea liassica.*
29.	Clay.			
30.	Hard grey limestone	0	6	"Fire-stone beds." Saurian remains and *Cardium.*
31.	Clay	0	2	*Modiola minima*, *Myacites*, and *Ostrea liassica.*
32.	Limestone	0	3	In these limestones and clays only *one* small *Ammonite* has been found.
33.	Clay	0	2	
34.	Limestone	0	3	
35.	Clay	0	3	
36.	Hard dark limestone, 1 in. to (This is the bottom bed of the quarry.)	0	10	"The Guinea-bed." Saurian bones, *Avicula longicostata*, Stutch., *Monotis decussata* (?), *Lima punctata*, *Myacites*, n. sp., *Ostrea liassica*, and *Hemipedina*, sp., in numbers; Coral.
37.	Thick clay-bed; yellowish blue; breaking in angular fragments	8	0	[Belonging to the zone of *Avicula contorta.*]
38.	Dark ferruginous clay, with conchoidal fracture	0	4	Estheria-bed. *Estheria minuta.*
39.	Clay	?		"Clear blue blocks."
40.	Laminated clays	3	0	
41.	Light-coloured sandstone; micaceous	0	1	*Pullastra arenicola*, Strickl.
42.	Brown clay	0	2	
43.	Sandstone; micaceous	0	2	*Pullastra arenicola*, Strickl.
44.	Dark shaly clay	0	6	
45.	Soft sandstone	0	1	
46.	Black clay	0	3	
47.	Ferruginous vein, sandy	?		
48.	Grey Keuper marls.			

The beds from No. 37 to No. 48 were found *in situ* in an escarpment at a short distance from the quarry at Binton. It must be understood that the "Guinea-bed" is the lowest bed seen *in situ* in the pit, and that No. 37 occupies its natural position relatively to that bed, although it is not exposed in the Binton section.

Lithology of the Ammonites planorbis *beds.*—The *Am. planorbis* beds at Brockeridge (p. 392) consist of dark laminated shales, with interstratified beds of marl and limestone. The shales split into very

thin laminæ, between which innumerable shells of *Ammonites planorbis* lie closely compressed; the white decomposed pulverulent matter of the shell forming a strong contrast to the dark shales which enclose them. In Somersetshire the rock consists, at Uphill, of shales which greatly resemble those at Brockeridge; at Watchet, of dark clays which are more indurated and have preserved better the shell-structure: here *Ammonites planorbis* and *Am. Johnstoni* are found with the iridescent nacreous layer of their shells beautifully preserved. At Street the rock is a light-yellowish clay, with bands of greyish limestone and marl beneath, and in Worcestershire at Strensham, and in Warwickshire at Binton, similar lithological conditions prevail.

The White Lias series of the Section at Saltford (see p. 400) represents the *Am. planorbis* beds: here also the relation of that zone to the Saurian beds below, and to the *Am. Bucklandi* beds above are well shown. In Dorsetshire the *Am. planorbis* beds are represented by the White Lias which is so well exposed in the large quarries at Up-Lyme, and in the coast-sections at Pinhay Bay and Axmouth. The White Lias is raised at Up-Lyme for caustic lime; it consists of a fine-grained cream-coloured limestone, apparently fit to be used as a lithographic stone. The two principal quarries afford the necessary details. Mr. Webb's quarry shows:—

1. (Uppermost.) The "Wetstone" (8 feet); consisting of thin bands of light-coloured limestone, interstratified with beds of clay. I collected *Lima gigantea*, Sow., and *Lima antiquata*, Sow., from the limestones.

2. The "Grey Bur" (14 inches); a good building-stone, consisting of two beds.

3. The "Rotten Bur" in two beds (6 inches); valueless, falling to pieces when exposed to the air.

4. The "Fire-stone" in two beds (6 inches); forming good flagstones.

5. The "Cliffage" (4 inches); worked for paving-stone; the surface of the rock is covered with many small Oysters (*Ostrea liassica*).

6. The "Half foot" (6 inches); 7. the "One foot" (12 inches); 8. the "Red Size" (7 inches); and 9. the "Anvil-edge" (18 inches) —are all employed for building-stones.

10. The "White Lias" (20 feet exposed); a compact earthy limestone, with a conchoidal fracture, cream-coloured and fine-grained; many of the beds are so hard and close-grained that it might be employed for the purposes of lithography. It contains very few fossils; sometimes specimens of *Ammonites Johnstoni*, Sow., are found in the marl-seams. The White Lias and its intervening marls measure from 18 to 20 feet in thickness in Mr. Webb's quarry.

In Mr. Fowler's quarry, about half a mile distant from the preceding, the White Lias is more fully exposed; it has here a thickness of from 18 to 20 feet and is underlaid by 18 inches of black shale, beneath which is a coarse blue Lias limestone. The beds above the White Lias are likewise here well exposed.

In these two sections the White Lias represents the zone of *Ammonites planorbis*, and the beds above, from the "Red size" upwards, the zone of *Ammonites Bucklandi*, consisting of alternate beds of limestone and marl, which have received special names from the workmen. Fragments of large *Ammonites* are sometimes found in these beds. I collected *Lima gigantea*, Sow., *Lima antiquata*, Sow., and an *Ostrea*.

At Pinhay Bay the clays above the White Lias contain numerous spines of Sea-urchins, and some tests with spines attached. I know the following *Echinodermata* from this bed: *Cidaris Edwardsii*, Wright, *Pseudo-diadema lobatum*, Wright, *Hemipedina Bechei*, Broderip, *Hemipedina Bowerbankii*, Wright.

Nearly all the Echinidæ of the Lias at Lyme are found in this bed of marl at low-water, after its surface has been exposed at spring-tides.

Localities of the Ammonites planorbis *beds*.—In Gloucestershire this zone is well exposed at Brockeridge Common. My friend Mr. J. Jones informs me that he has found it at Wainlode, in a quarry on the right-hand side of the road to Gloucester, ascending the hill from the inn;—between Hartpury and Ashelworth, where he found *Am. planorbis* in a brownish-blue clay, which split into thin laminæ and contained numerous impressions of this shell;—at Elmore, in quarries near the Old Kennel, in a light-coloured clay, and in one of the lower bands of claystone.

In Glamorganshire, it is seen in the fine coast-section at Penarth Head (see page 381). In Somersetshire, in the cutting of the Great Western Railway at Saltford (p. 399); in the Uphill Cutting on the Bristol and Exeter Railway (p. 382); in the coast-section at Watchet (p. 384); and in all the quarries at Street (p. 390), where it forms the top beds.

In Worcestershire it is found at Strensham (p. 393); and in Warwickshire at Binton (p. 394), Grafton, and Wilmcote (p. 386).

It is likewise found at Robin Hood's Bay on the coast of Yorkshire; the beds here lie below low-water mark; but large blocks, frequently washed up by the tide, are literally crowded with *Ammonites planorbis*, known at Scarborough and Whitby as *Am. erugatus*, Bean.

The coral-bed at Lussay, Isle of Skye*, probably represents this *Am. planorbis* zone, as I found the same species as the Hebridean coral in the light-coloured clays with *Am. planorbis* at Street.

This lowest Ammonite-zone has, therefore, a wide geographical distribution throughout the Lower Lias of the Northern, Midland, and Southern Counties of England, and it retains the same relative position in the Lower Lias of France, Germany, and Switzerland.

Fossils of the Ammonites planorbis *beds*.—The fauna of this zone is very limited; at present I know only the following species:—

Ichthyosaurus intermedius, *Conyb.*
—— tenuirostris, *Conyb.*
—— communis, *Conyb.*
Plesiosaurus Hawkinsii, *Conyb.*
—— Etheridgii, *Huxl.*
—— rugosus, *Ow.*

* Quart. Journ. Geol. Soc. vol. xiv. pp. 4 & 34.

Plesiosaurus dolichodeirus, *Conyb.*
—— megacephalus, *Stutch.*
Dapedius.
Pholidophorus leptocephalus, *Ag.*
—— Stricklandi, *Ag.*
Ammonites planorbis, *Sow.*
—— Johnstoni, *Sow.*
Lima punctata, *Sow.*
—— gigantea, *Sow.*
—— pectinoides, *Sow.*
Cardinia crassiuscula, *Sow.*
Unicardium cardioides, *Phil.*
Rhynchonella variabilis, *Schloth.*
Cidaris Edwardsii, *Wr.*
Pseudo-diadema lobatum, *Wr.*
Hemipedina Bechei, *Brod.*
—— Bowerbankii, *Wr.*
—— Tomesii, *Wr.*
Isastræa Murchisoni, *Wr.*

2. The Zone of Ammonites Bucklandi, or the Lima-beds.

Synonyms.—"Blue Lias," William Smith, Memoir to the Map, 1815. "Blue Lias Limestone," De la Beche, Geol. Trans. vol. ii. 2nd series, 1829. "Gryphiten-Kalkstein," Alberti, Die Gebirge des König. Württemberg, p. 121, 1826. "Liaskalk," Mandelsloh, Geol. Profile der schwäbisch. Alpen, p. 28, 1834. "Calcaire à Gryphée arquée" (pars), Dufrénoy et de Beaumont, Mém. Soc. Géol. de France, 1830. "Grès de Luxembourg (pars sup.)," Omalius d'Halloy. "Grès de Luxembourg," Dewalque, Descrip. du Lias de la Luxembourg, p. 28, 1857. "Plagiostoma-beds, Lower Lias," Murchison, Geol. of Cheltenham, 2nd ed. p. 49, 1845. "Arietenkalk," Quenstedt, Der Jura, Table, p. 293, 1857. "Die Schichten des Ammonites Bucklandi," Oppel, Juraformation, p. 35, 1856.

The zone of *Ammonites Bucklandi* (or *Lima*-beds) forms an important subdivision of the Lower Lias. This series attains a great development in the Midland Counties, in Glamorganshire, Somerset, and Dorset. This zone of life is characterized throughout by the prevalence of a number of large *Ammonites* belonging to the natural group *Arietes* (von Buch), and by many *Conchifera* of the genera *Lima* and *Gryphæa*. In England it everywhere consists of beds of bluish argillaceous limestone, interstratified with beds of marl, shale, and clay of a similar colour. In some parts of Warwick, Somerset, Dorset, and Glamorgan, this series attains a thickness of 80 feet.

Gloucestershire and Somersetshire.—In Gloucestershire it has been chiefly exposed by the deep cutting of the Dean Forest Railway near Gloucester, in the Lias limestone-quarries near Tewkesbury, and in the natural escarpments at Frethern and Purton-on-the-Severn. In Somersetshire it was admirably exposed in making the Great Western Railway between Bristol and Bath, and probably at no point were the several beds of the *Lima* series better shown than in the cutting at Saltford, seven miles from Bristol. My friend Mr. William Sanders made the following section during the executiou of the works, which, together with his notes on the fossils contained in the different strata, has been kindly communicated by my friend Mr. Etheridge. This section is of great value, inasmuch as the beds are now partially concealed by *débris* and vegetation, and the characteristic fossils can no longer be found in their respective beds.

Section of the Lower Lias Beds at Saltford, seven miles from Bristol, on the Great Western Railway.*

No.	Lithology.	Thickness. feet.	Organic Remains.
	Brown gravelly marl	120	
	Beds of laminated shale and clay	110	
	Dark clay, with boulders, and with layers of septaria at the top and bottom of the bed, and in the clay between.........	105	Scales of *Tetragonolepis* and *Belemnites acutus*, Mill.
59.	Grey Lias limestone	100	*Rhynchonella variabilis*, Schl.
58.	Dark shale		*Belemnites acutus*, Mill.
	Grey Lias limestone.		
	Dark shale		*Ostrea læviuscula*, Sow., *Avicula*, and *Pecten*.
57.	Grey Lias limestone		*Ammonites Conybeari*, Sow., and *Belemnites acutus*, Mill.
	Dark shale.		
56.	Thin limestone-band.		
	Dark limestone		*Nautilus striatus*, Sow., *Am. Conybeari*, Sow., and *Belemnites acutus*, Mill.
55.	Grey Lias limestone	95	*Lima gigantea*, Sow., and *Spirifera Walcotti*, Sow.
	Dark limestone.		
54.	Grey Lias limestone.		
	Dark shale.		
53.	Grey Lias limestone.		
	Dark laminated shale.		
52.	Dark-grey Lias limestone...		Vertebræ of *Ichthyosaurus*, *Am. Bucklandi*, and *Spirifera Walcotti*.
	Dark shale		*Am. Bucklandi*, *Nautilus striatus*, and *Spirifera Walcotti*.
51.	Grey Lias limestone	90	
	Dark shale.		
50.	Grey Lias limestone		*Hybodus curtus*, Agass.
	Dark shale		*Pholadomya glabra*, Agass.
49.	Grey Lias limestone		*Nautilus striatus*, Sow. (large), *Am. Brookii*, Sow., and fossil wood.
	Dark shales		*Am. Conybeari*, Sow., and *Am. Bucklandi*, Sow.
48.	Grey Lias limestone		*Pleurotomaria similis*, Sow., and *Lima gigantea*, Sow.
	Dark shales		*Am. Bucklandi*, Sow., and *Pleurotomaria similis*, Sow.
47.	Grey Lias limestone.		
	Dark shales	85	*Ammonites Conybeari*, Sow.
46.	Grey Lias limestone		*Nautilus striatus*, Sow. (large).
	Dark shales		*Pentacrinus* (stem) and *Pecten textorius*, Goldf.

* This section shows the relative position of the zones of *Ammonites Bucklandi* and *Am. planorbis* and the *Avicula contorta* series in this part of the county of Somerset, and affords a good type for comparing these zones in Somersetshire with the same groups in other parts of the South of England

	No.	Lithology.	Thickness. feet.	Organic Remains.
	45.	Dark-grey limestones		*Ichthyosaurus communis*, Conyb.
		Dark shales		*Gryphæa incurva*, Sow., and *Pentacrinus tuberculatus*, Mill.
	44.	Grey limestone.		
		Dark shales.		
	43.	Grey limestone		*Ichthyosaurus communis* and *Am. Conybeari.*
		Dark shales		*Pinna Hartmanni*, Ziet., and *Gryphæa incurva*, Sow.
	42.	Bluish limestone............	80	
	41.	Thirteen or fourteen limestone-bands, with irregular surfaces; some nodular, with partings of clay and shale	75	*Pholadomya glabra*, Ag., and *Lima*, n. sp., with large ribs, *Gryphæa incurva*, Sow., and *Rhynchonella variabilis*, Schl.
	40.	From six to eighteen beds, comprising 20 inches of stone	70	*Pholadomya glabra*, Ag., and *Lima gigantea*, Sow.
	39.	Fourteen beds of limestone and clay		*Pecten textorius*, Schl., *Pholadomya glabra*, Ag., and *Pleurotomaria similis*, Sow.
	38.	Eight beds of limestone and clay		*Lima pectinoides*, Sow., and *Cardinia ovalis*, Stutch.
	37.	Thirteen beds of limestone and clay; the limestones irregular, water-worn, and nodular	65	*Pholadomya glabra*, Ag., *Rhynchonella variabilis*, Schl., and *Ostrea.*
		Dark laminated shales ...		*Ostrea.*
	36.	Grey limestone.		
		Dark shales.		
	35.	Greyish limestone	60	
	34.	Ten beds of shales and limestone; septaria in the lower beds.		
	33.	Thin grey limestone.		
		Thick dark clay.		
	32.	Thin band of limestone.		
		Dark clay.		
	31.	Thin band of limestone	50	
		Thick dark shales.		
	30–25.	Six beds of limestone, alternating with six thicker beds of clay ...	43	
White Lias Series, 32 feet in thickness.	24.	Light-coloured limestone.		
		Dark-coloured shale.		
	23.	Light-coloured limestone.		
		Dark shale.		
	22.	Thick White Lias	40	
	21–12.	Twelve beds of White Lias, separated by thin bands of clay	35	*Pinna Hartmanni*, Ziet., and *Unicardium cardioides*, Phil.
	11, 10.	Four beds of limestone, becoming thin and rubbly beneath, and nodular at the base	30	*Pecten textorius*, Goldf., and *Pholadomya glabra*, Ag., *Modiola Hillana*, Sow., and *Avicula* (small).
	9.	Cotham marble	25	

	No.	Lithology.	Thickness. feet.	Organic Remains.
Avicula contorta Series, 25 feet in thickness.		Black shales.		
	8.	Band of limestone	20	
	7.	Nodular limestone.		
		Black shales..............	15	Fishes' scales; layers of compressed *Pullastra arenicola*, Strickl.
	6.	Dark limestone	10	*Pecten Valoniensis*, Defr., and *Avicula contorta*, Portl.
		Dark shale.		
	5.	Dark limestone		*Pullastra arenicola.*
		Dark shale.		
	4.	Greenish brown soft? Marlstone.		
	3.	Pale-bluish clay, with plant-like fibres	5	
	2.	Buff-coloured clay.		
	1.	Grey sandy marlstone, with ferruginous spots.		
		New Red Marl.		

Lyme Regis.—The zone of *Ammonites Bucklandi* is admirably exposed in the coast-section at Lyme Regis in Dorset, both in the Church Cliffs and at Pinhay Bay, where the beds consist of a series of grey limestones, from 2 to 10 inches in thickness, varying from earthy to compact, and alternating with marls and shaly beds,—either seams of a few inches, or beds of many feet in thickness. The following section, from the lowest bed on the shore to Broad Ledge, which may be considered as the uppermost bed of the *Am. Bucklandi* or *Lima* series, affords a correct view of the stratigraphical order of these strata and of the fossils they contain.

Section of the Ammonites Bucklandi *or* Lima *beds from Broad Ledge to the shore at Lyme Regis.*

	No.	Lithology.	ft.	in.	Organic Remains.
Am. Turneri Beds.	1.	Dark-grey limestone. "Broad Ledge" or "Table-bed"	3	6	*Rhynchonella variabilis*, in masses.
	2.	Dark marls and shales, with bands of clays	15	0	*Ichthyosaurus communis*, *I. platyodon*, *Ammonites semicostatus*, Y. & B., and *Rhynchonella variabilis*, Schl.
	3.	Grey limestone	0	4	*Ammonites Turneri*, Sow., and *Am. semicostatus*, Y. & B.
	4.	Dark slaty marls	4	0	
Am. Bucklandi or *Lima* Beds.	5.	Dark-grey limestone......	1	0	*Lima gigantea*, *L. antiquata*, and *Rhynchonella variabilis*.
	6.	Black shales, with partings of gypsum	2	6	*Ichthyosaurus communis* (in the "firestone-beds" west of the Cobb).
	7.	Dark-greyish limestone .	0	10	*Lima gigantea*, *L. antiquata*, and *Rhynchonella variabilis*.
	8.	Dark shale.................	2	0	*Gryphæa incurva*, Sow.
	9.	Hard grey limestone. "Grey Ledge"	1	3	Fin-spines of *Hybodus*, *Rhynchonella variabilis*, and *Pentacrinus* (stem).
	10.	Dark shaly marls	2	0	*Ichthyosaurus platyodon*.
	11.	Grey limestone	0	6	Spines of *Pseudo-diadema*, and other *Echinidæ*.
	12.	Dark indurated shale ...	3	6	*Ichthyosaurus platyodon*.

Ammonites Bucklandi or *Lima* Beds.

No.	Lithology.	ft.	in.	Organic Remains.
13.	Bluish limestone	1	0	*Gryphæa incurva, Rhynchonella variabilis,* and *Lima antiquata.*
14.	Dark shales, containing indurated imperfect limestone	1	6	*Ichthyosaurus communis, I. platyodon, Pentacrinus tuberculatus,* Mill., and *Lima gigantea,* Sow.
15.	Bluish limestone	0	10	
16.	Dark indurated clay......	1	3	*Gryphæa incurva* and fragments of *Pentacrinus tuberculatus.*
17.	Grey limestone, with the plant-bed at the top ...	0	6	*Otopteris obtusa,* L. & H., and *Araucarites peregrinus,* Sternb., in the plant-bed.
18.	Dark-bluish limestone ...	1	6	*Ammonites Conybeari* and *Rhynchonella variabilis.*
19.	Dark shale..................	0	8	*Gryphæa incurva,* Sow.
20.	Dark-greyish limestone .	0	10	*Ammonites Bucklandi,* Sow., and *Am. rotiformis,* Sow.
21.	Dark shale..................	0	8	
22.	Grey limestone	0	4	
23.	Dark shale..................	1	0	*Ichthyosaurus tenuirostris,* Conyb.
24.	Dark-greyish limestone .	1	4	*Ichthyosaurus communis,* skulls and bones of other species, and *Rhynchonella variabilis.*
25.	Hard shale, forming "Quick Ledge"	1	6	*Ichthyosaurus communis* and *I. intermedius.*
26.	Blue limestone	0	6	*Ammonites Bucklandi* and *Lima gigantea.*
27.	Dark shale..................	0	8	*Gryphæa incurva* and *Rhynchonella variabilis.*
28.	Concretionary limestone (surface mammillated)	0	4	
29.	Dark-grey shale...........	0	8	*Ammonites angulatus,* Schl.
30.	Greyish limestone.........	0	6	*Lima gigantea* and *L. antiquata.*
31.	Dark indurated shale	0	9	*Ammonites Bucklandi* (large specimens on the shore).
32.	Hard grey limestone......	0	7	*Lima gigantea* and *L. antiquata.*

The shingle of the shore covers the lower beds.

Coast of Glamorganshire.—In Glamorganshire there is an extensive exposition of the *Am. Bucklandi* and *Lima* series for the distance of sixteen miles along the coast, from Penarth Head by Barry Island, Aberthaw, and Dunraven Castle to the mouth of the River Ogmore, where the Lower Lias rests on upturned beds of Carboniferous Limestone. The strata chiefly laid bare by the sea are those containing *Lima gigantea* and *Gryphæa incurva.* At Cowbridge the same lithological relations are observed; the Lower Lias here rests on Carboniferous Limestone.

At Penarth Head, however, the relation of the *Am. Bucklandi* series to the *Am. planorbis* and *Avicula contorta* beds below is much better seen than at any other part of the Glamorganshire coast.

Fossils of the zone of Ammonites Bucklandi.—The fossils of the zone of *Ammonites Bucklandi* are numerous, and in general in a good state of preservation.

Ichthyosaurus communis, *Conyb.*
—— intermedius, *Conyb.*
—— platyodon, *Conyb.*
—— tenuirostris, *Conyb.*

Ichthyodorulites of Hybodus.
Ammonites Bucklandi, *Sow.*
—— Conybeari, *Sow.*
—— rotiformis, *Sow.*

Ammonites angulatus, *Schloth.*
—— Greenoughii, *Sow.*
—— tortilis, *d'Orb.*
Nautilus striatus, *Sow.*
Pleurotomaria similis, *Sow.*
Ostrea irregularis, *Münst.*
Gryphæa incurva, *Sow.*
Unicardium cardioides, *Phil.*
Pecten textorius, *Schloth.*
Lima gigantea, *Sow.*
—— antiquata, *Sow.*
—— pectinoides, *Sow.*
Modiola Hillana, *Sow.*
Avicula Sinemuriensis, *d'Orb.*
Pinna diluviana (*Zieten*, pl. 55. fig. 6).
Pholadomya glabra, *Agass.*
Terebratula psilonoti, *Quenst.*
Rhynchonella variabilis, *Schloth.*
Spirifera Walcotti, *Sow.*
Pseudo-diadema (spines).
Cidaris Edwardsii, *Wr.*
Pentacrinus tuberculatus, *Mill.*
Isastræa Murchisoni, *Wr.*

3. The Zone of Ammonites Turneri.

Synonyms.—"Hauptpentacrinitenbank des untern Lias," Quenstedt, Flözgeb. p. 152, 1843. "Lumachelle de Pentacrinites basaltiformis," Marcou, Jura salinois, p. 47, 1846. "Die Schichten des Pentacrinus tuberculatus," Oppel, Juraformation, p. 44, 1856. "Tuberculatus-bed," Wright, Quart. Journ. Geol. Soc. vol. xv. p. 25, 1858. "Marne de Strassen," Dewalque et Chapuis, Fossiles de Luxembourg, 1853. "Marne de Strassen," Dewalque, Descrip. du Lias de Luxembourg, 1857.

This subdivision of the Lower Lias forms a well-marked zone of life. The beds consist of light-coloured argillaceous limestone, of hard greyish limestone, or of deep-blue, shelly, indurated shale, interstratified with beds of dark-coloured clay. Many of the slabs of limestone are covered with shells and portions of the stem and side arms of *Pentacrinus tuberculatus.* From one of these slabs, collected at Frethern or Purton in Gloucestershire, Miller's original specimen of this Crinoid was obtained.

Gloucestershire and Warwickshire.—The zone of *Ammonites Turneri* was exposed at Bredon, in the deep cuttings of the Midland Railway, from whence many of my specimens were obtained. Portions of these beds are sometimes laid open in the Vale of Gloucester in making drains, as at Badgeworth and Hardwick ; and many fine slabs are occasionally procured from the river-section at Purton. I know of no locality in Gloucestershire, however, where the entire series is exposed. My friend Dr. Oppel referred the Saurian beds of Brockeridge Common to this series, supposing them to be the equivalent of the Saurian beds at Lyme, which appertain to the zone of *Ammonites Turneri* ; but the description which I have already given of the *Am. planorbis* beds and their correlations have demonstrated that the beds at Brockeridge Common represent the *Am. planorbis* series. In Warwickshire the *Am. Turneri* beds constitute the base of what is called in that county the "Cardinia-series," which includes all those strata of the Lower Lias extending from the *Am. Turneri* to the *Am. raricostatus* beds, and which are characterized by different forms of *Cardinia Listeri*, Sow.

Dorsetshire.—At Lyme Regis the *Ammonites Bucklandi* or *Lima* series is overlain by thick beds of clay and slaty marls containing many Enaliosaurian skeletons, with numerous fishes, in fine preservation ; these strata are known to local collectors as the Fish- and

Saurian-beds. The magnificent specimen of *Ichthyosaurus platyodon*, Conyb., now in the British Museum, came from this clay, as proved by the impressions of *Am. semicostatus*, Y. & B., which are seen on the matrix. This thick clay-bed is underlain by a thin band of greyish limestone, in which *Am. Turneri* is found. The following section of this zone at Lyme Regis shows the sequence of the *Am. Turneri* beds at that locality.

Section of the Zone of Ammonites Turneri *at Lyme Regis.*

	No.	Lithology.	ft.	in.	Organic Remains.
Beds with *Ammonites Turneri.*	1.	Thick limestone. "Broad Ledge"	3	6	
	2.	Black shales, with bands of brown clay. "Saurian- and Fish-bed"	18	0	*Ichthyosaurus platyodon*, *I. communis*, *Ammonites semicostatus*, *Am. Turneri*, and Fishes.
	3.	Greyish, hard, shelly limestone	0	4	*Ammonites Turneri* and *Am. semicostatus*.
	4.	Dark shales, with indurated bands of imperfect limestone	3	0	
		Greyish limestone			*Lima gigantea*, *L. antiquata*, and *Rhynchonella variabilis*.

Beds with *Am. Bucklandi* and *Lima*. (See page 398.)

Fossils of the Zone of Ammonites Turneri *.

Ichthyosaurus platyodon, *Conyb.* (British Museum).
—— intermedius, *Conyb.* (Warwick Museum).
—— communis, *Conyb.* (Brit. Mus.).
Ammonites Turneri, *Sow.*
—— semicostatus, *Y. & B.*
—— Bonnardi, *d'Orb.*
Turbo.
Lima punctata, *Sow.*
—— gigantea, *Sow.*
—— pectinoides, *Sow.*
Cardinia ovalis, *Stutch.*
Ostrea.
Avicula.
Pecten textorius, *Schloth.*
—— glaber, *Hehl.*
Astarte consobrina, *Dewal.*
Crenatula.
Plicatula.
Gervillia lanceolata, *Sow.*
Gryphæa obliqua, *Sow.*
Cidaris Edwardsii, *Wr.*
Pentacrinus tuberculatus, *Miller.*

4. The Zone of Ammonites obtusus.

Synonyms.—"Marston-Marble," Sowerby, Min. Con. Suppl. Index, vol. i. 1812. "Ammonite-bed (Lower Lias)," Murchison, Geol. of Cheltenham, 2nd edit. p. 42, 1845. "Turneri-Thone," Quenstedt, Flözgeb. Württembergs, p. 540. "Sable d'Aubange (pars infer.)," Dewalque et Chapuis, Luxembourg, p. 12. "Grès de Virton (pars infer.)," Dewalque, Lias de Luxembourg, p. 48. "Die Schichten des Ammonites obtusus," Oppel, Juraformation, p. 50. "Indurated marl and limestone-beds," De la Beche, Sections, &c., Geol. Trans. 2nd ser. vol. ii.

Gloucestershire and Warwickshire.—The beds constituting this zone are well developed in the Vale of Gloucester, and were exposed in the deep cuttings of the Bristol and Birmingham Railway, especially near Bredon, from whence the best collection of the fossils of

* I have omitted the fossil Fishes found in the Lias at Lyme Regis, as I was unable to ascertain with correctness the beds from which the different species were collected: a large majority of them, I believe, come from this zone of life.

these beds was obtained. The rocks consist of dark-grey or bluish shales and clays, with irregular and inconstant beds of dark-grey argillaceous limestone, the shales being in parts nodular or laminated, the clays thick and tenacious; the nodular portions of the shales were very fossiliferous. This zone forms part of the Cardinia-bed of the local geologists in Warwickshire, where it appears to be exposed in several localities. I saw in Mr. Tomes's collection some very fine specimens of *Ammonites obtusus, Am. multicostatus, Am. Brookii*, and *Am. Sauzeanus*, d'Orb., collected by him from the *Am. obtusus* beds; and in Mr. Kershaw's collection I saw a series of *Am. Sauzeanus*, d'Orb., from Darlingstoke near Shipton-on-Stour.

Dorsetshire.—At Lyme Regis the zone of *Ammonites obtusus* attains a considerable thickness, and is well exposed in the coast-section. The beds rise on the shore about half a mile east of Charmouth, and consist of thick beds of dark marls, which rest upon the Table-bed, formed by Broad Ledge. The lower part of these marls contain numerous compressed *Ammonites* and layers of nodules forming cement-stones. Above these succeed shales and clays, thin bands of limestone, and thick beds of shale and marls with mudstones. Above these are inconstant bands of limestone containing septaria, in which gigantic examples of *Am. obtusus, Am. stellaris*, and *Am. Brookii* are found. The following section shows the relative position of these beds.

Section from Broad Ledge to Cornstone Ledge, near Charmouth.

No.	Lithology.	ft.	in.	Organic Remains.
1.	Dark-grey limestone. "Cornstone Ledge."			
2.	Dark-bluish marls	20	0	
3.	Dark-greyish limestone	0	10	*Ichthyosaurus platyodon* and *I. intermedius.*
4.	Dark clays.			
5.	Dark limestone, with septaria.			*Nautilus striatus, Ammonites Brookii*, and *Am. stellaris* (very large).
6.	Dark shale.			
7.	Dark limestone. "Upper Cement-bed."			
8.	Dark shales, containing mudstone nodules.			*Inoceramus.* Saurian remains.
9.	Thin band of limestone. "The Pentacrinite-bed."			*Extracrinus Briareus.*
10.	Dark shales. } "Fire-ledge."			
11.	Dark limestone. } "Fire-ledge."			
12.	Dark shale. } "Fire-ledge."			
13.	Dark limestone. } "Fire-ledge."			
14.	Dark shale. "Split-ledge."			
15.	Dark limestone			*Ammonites planicosta*, Sow., and *Am. Smithii*, Sow.
16.	Dark shales			Saurian skeletons.
17.	Greyish limestone..............			*Ammonites obtusus*, Sow., and *Am. Birchii*, Sow., crystallized, forming the "Tortoise-ammonites."
18.	Dark marls, with nodular masses	20	0	The nodules of these lower cement-beds contain Saurian remains.
19.	Dark indurated shale and limestone. "Broad Ledge."	4	0	Overlies the Lima-beds east of Lyme.

The zone of *Ammonites obtusus* probably attains a thickness of from 80 to 100 feet; but its actual measurement would be a matter of difficulty, from the manner in which the marls have covered over the bands of limestone: hence the imperfection of our estimate.

In the lower slaty marls are numerous compressed *Ammonites Birchii*, which fall to pieces when removed from the matrix. Higher up (No. 17) the same species is found in fine preservation, with *Ammonites obtusus*. Here the shells are replaced, and the septa filled, with crystallized carbonate of lime. These beautiful specimens are the "Tortoise-ammonites" of the local collectors. About 40 or 50 feet above these beds is an irregular band of limestone (5), projecting from the cliff, containing nodules with very large specimens of *Ammonites obtusus*, Sow., *Am. stellaris*, Sow., and *Am. Brookii*, Sow. Most of the nodules have a septarian structure, the veins of spar intersecting and distorting the shape of the Ammonite.

Below the Ammonitiferous nodules (5 of the section) other bands of clay and marl (6 to 14) succeed. In one of these (9) are thin layers of Crinoidal limestone, on the surface of which magnificent specimens of *Extracrinus Briareus*, Mill., are found, with their plant-like arms laid out in all directions, and generally coated with sulphuret of iron.

Fossils of the Zone of Ammonites obtusus.

Ammonites obtusus, *Sow.*	Ammonites Smithii, *Sow.*
—— Brookii, *Sow.*	Nautilus striatus, *Sow.*
—— stellaris, *Sow.*	Belemnites acutus, *Mill.*
—— planicosta, *Sow.*	Pleurotomaria Anglica, *Sow.*
—— Dudressieri, *d'Orb.*	Extracrinus Briareus, *Mill.*

5. The Zone of Ammonites oxynotus.

Synonyms.—"Oxynoten-Schichte," Fraas, Württemb. naturw. Jahreshefte, 1847, p. 206. "Oxynotenlager," Quenstedt, Der Jura, p. 293, 1858. "Die Schichten des Ammonites oxynotus," Oppel, Die Juraformation, p. 54, 1856. "Oxynotus-bed," Wright, Quart. Journ. Geol. Soc. vol. xiv. p. 25, 1858.

This zone consists of beds of dark clays, often containing much sulphuret of iron, or iron in the state of peroxide, all the fossils found in the clay being either highly pyritic, or charged with peroxide of iron. The bed was exposed in the cuttings of the Bristol and Birmingham, and Great Western Railways, at Lansdown near Cheltenham, and likewise in excavating the new docks at Gloucester; and I have collected its characteristic fossils at other localities in the Vale of Gloucester.

In Dorsetshire a variety of *Ammonites oxynotus*, Quenst., is found in a thin bed of dark pyritic marl between Charmouth and Lyme Regis, near Black Venn. It is here collected with other species, which properly belong to a higher bed: the falling down of the marl, by the decay of the bank, makes it difficult to separate the beds.

At Robin Hood's Bay, on the Yorkshire coast, the relative position of this zone to the beds with *Ammonites obtusus*, Sow., below, and

Ammonites raricostatus, Ziet., above, are seen in the cliff near the point where the road leads up to the Alum-works. At this locality the *Am. oxynotus* bed is about 20 feet above the clays with *Am. obtusus.*

Ammonites oxynotus, *Quenstedt.*

Fossils of the Zone of Ammonites oxynotus.

Ammonites oxynotus, *Quenst.*	Plicatula ventricosa, *Münst.*
—— bifer, *Quenst.*	Modiola minima, *Sow.*
—— lacunatus, *Buck.*	Arca.
Nautilus striatus, *Sow.*	Leda.
Belemnites acutus, *Mill.*	Acrosalenia minuta, *Buck.*
Pleurotomaria Anglica, *Sow.*	—— cidaris; spines.

6. The Zone of Ammonites raricostatus.

Synonyms.—"Hippopodium-bed (in part)," Murchison's Geology of Cheltenham, 2nd ed., by Buckman and Strickland, p. 44. "Raricostatenschichte," Fraas, Württemb. naturw. Jahreshefte, 1847, pl. 3. "Raricostatenbank," Quenstedt, 1856, Der Jura, p. 292. "Die Schichten des Ammonites raricostatus," Oppel, 1856, Die Juraformation, p. 56.

The beds forming this zone are exposed in several brick-fields in the vicinity of Cheltenham. They consist of dark-coloured clays, more or less impregnated with the peroxide of iron. In an excavation recently made near Marle Hill, for the purpose of obtaining clay to make bricks for the town-sewers, the following section was obtained. The beds are enumerated in a descending order.

No.		ft.	in.
1.	*Gryphæa-bed*; a hard ferruginous clay, which broke into fragments, and contained many specimens of *Gryphæa obliquata*, Sow. ....3 ft. to	4	0
2.	*Coral-band*; a thin seam of lightish-coloured unctuous clay, containing a great many small sessile Corals (*Thecocyathus*), most of which appeared to have been attached to the valves of *Gryphites* ......1 inch to	0	$1\frac{1}{2}$
3.	*Hippopodium-bed*; a stiff dark-coloured clay, in some parts ferruginous, and containing *Cardinia Listeri*, Sow., and *Hippopodium ponderosum*, Sow., in considerable numbers .... from 8 ft. to	10	0
4.	*Ammonite-bed*; a dark ferruginous clay, containing selenite and the peroxide and sulphuret of iron, and a great number of the brood of *Ammonites*, highly pyritic, likewise *Am. raricostatus*, *Am. armatus*, and the other species of the list.......................	Not ascertained.	

In the parish of Cleeve near Cheltenham the same beds were formerly worked for brick-earth, and the finest specimens that I have collected of *Cardinia Listeri*, Sow., *Hippopodium ponderosum*, Sow., *Ammonites raricostatus*, Ziet., and *Pleurotomaria Anglica*, Sow., were obtained therefrom. In the railway-cutting at Bredon the same beds were likewise cut through, and yielded a rich series of the characteristic fossils. In Warwickshire the railway-cutting at Honeybourne exposed the same beds; and here likewise the coral-band contained a considerable number of *Thecocyathus rugosus*, Wr.

At Lyme Regis in Dorsetshire this zone is found near Black Venn. Some of the beds contain a considerable quantity of pyrites, so much so, that during the winter months they are worked for that mineral, when their characteristic *Ammonites* are collected in considerable numbers; unfortunately they are so much charged with pyrites that they are preserved with difficulty.

At Robin Hood's Bay, on the coast of Yorkshire, this zone is seen resting on the underlying clays with *Ammonites oxynotus*, and overlain by thick clays containing *Ammonites Jamesoni*, Sow. In all these localities there appears to be an absence of limestone-layers; clay, more or less impregnated with iron, constitutes the entire beds.

Fossils of the Zone of Ammonites raricostatus.

Belemnites acutus, *Mill.*
Nautilus striatus, *Sow.*
Ammonites raricostatus, *Ziet.*
—— armatus, *Sow.*
—— armatus densinodus, *Quenst.*
—— nodulosus, *Buck.*
—— Guibalianus, *d'Orb.*
—— muticus, *d'Orb.* (?)
Pleurotomaria similis, *Sow.*
Trochus imbricatus, *Sow.*
Ostrea, n. sp.
Gryphæa obliquata, *Sow.*
Cardinia Listeri, *Sow.*
Hippopodium ponderosum, *Sow.*
Anomya pellucida, *Terq.*
Unicardium cardioides, *Phil.*
Myacites, sp.
Rhynchonella variabilis, *Schloth.*
Terebratula numismalis, *Lamk.*
Pentacrinus scalaris, *Goldf.*
Thecocyathus rugosus, *Wr.*

§ IV. *Conclusion.*—From the preceding observations it appears

that the Avicula contorta beds, which lie at the base of the Lias, contain a fauna of a special character; several of the *Conchifera* are identical with species found only in the Upper St. Cassian beds and Kössener-Schichten of continental geologists. These remarkable strata are grouped by one class of observers with the Trias, by another with the Lias; the difference of opinion among continental geologists has arisen from the circumstance that the majority of the species have a Triassic facies, whilst a few only are said to pass into the Lias.

In England, on the contrary, our grouping of the *Avicula contorta* beds has been based chiefly on their lithological character; and in part likewise from their being fossiliferous, and resting on the uppermost part of the unfossiliferous Red Marl; the fossils they were found to contain being assumed to be Liassic, from their proximity to the fossiliferous beds of the Lias.

It has been stated by Sir Philip Egerton and Professor Agassiz, that the Fishes of the English Bone-bed are either special to that breccia, or belong to species which are well known in the Muschelkalk of Germany. General Portlock, who found these beds in the North of Ireland, stated that they contained Muschelkalk fossils; and Sir Charles Lyell, in his 'Manual,' from the determination of the Fish, placed the Bone-bed in the Trias. Lastly, I have now shown that the *Conchifera* are special to this zone, and that none of them appear to pass into the true Lias.

The *Avicula contorta* beds occupy a considerable area in the Midland Counties, the South of England, and South Wales, and throughout present very uniform lithological and palæontological characters; General Portlock having found them in the North of Ireland, and Mr. Howell at Bagots Park in Staffordshire, whilst I have traced them through the counties of Worcester, Warwick, Gloucester, Somerset, Glamorgan, and Dorset.

Whatever may be determined regarding the true grouping of the *Avicula contorta* beds, there can be no doubt that the Zone of Ammonites planorbis belongs to the Lias, and forms the base of that formation, should the *Avicula contorta* beds be hereafter removed to the Trias. This zone is remarkable for the *first appearance of Ammonites* under the simple form of *Ammonites planorbis* in some of its lowest beds, where they appear sparingly. They are abundant in the upper shales, where the species become extinct. The *Am. planorbis* beds may be described as the first Saurian zone of the Lias, if the Bone-bed be removed from this formation. *Plesiosaurus megacephalus*, *P. Etheridgii*, *P. Hawkinsii*, and *P. dolichodeirus* are found in the Lower "Fire-stones;" and *Ichthyosaurus intermedius* and *I. tenuirostris* in the shales and limestones above these. Insects are found in different beds in this zone in some localities, and only in one or two limestone-beds in others. The thin laminated shales are often much marked by rain-spots. These facts attest the marginal nature of these deposits. The numerous Sea-urchins of the "Guinea-bed" and the corals of the other strata prove that marine life there prevailed.

The Zone of Ammonites Bucklandi is remarkable for containing a great number of large *Ammonites* belonging to Von Buch's group *Arietes*, such as *Am. Bucklandi*, *Am. rotiformis*, *Am. Conybeari*, *Am. angulatus*, &c., which everywhere characterize this stage where it is developed in Europe. Saurian remains are not so abundant in this as in the *Am. planorbis* zone; but *Lima gigantea*, *L. antiquata*, and other congeneric forms, with *Gryphæa arcuata*, prevail in abundance throughout. In the uppermost beds only *Belemnites acutus* occurs, and that in small numbers.

The Zone of Ammonites Turneri is characterized by the appearance of several species of *Ammonites*, as *Am. Turneri* and *Am. semicostatus*, and the abundance of a remarkable crinoid, *Pentacrinus tuberculatus*, Mill. The *Ammonites* which prevailed in the *Am. Bucklandi* zone are mostly all absent from this. The second Lias Saurian zone belongs to this subdivision, for the beds richest in remains of Fish and Saurians at Lyme Regis (containing *Ichthyosaurus platyodon*, *I. intermedius*, and *I. communis*) belong to the zone of *Am. Turneri*. Unfortunately the beds yielding the different species of fossil Fishes have not been noted with sufficient accuracy to enable me to state what species belong in particular to these beds.

The Zone of Ammonites obtusus contains many species of *Ammonites* which here appear for the first time. *Ammonites obtusus*, *Am. Birchii*, *Am. Brookii*, *Am. Smithii*, *Am. Dudressieri*, and *Am. planicosta*, with *Nautilus striatus* and *Belemnites acutus*, form the group of *Cephalopoda* here. Saurian bones occur sparingly in these beds; and a remarkable thin bed of limestone, characterized by immense numbers of *Extracrinus Briareus* which are preserved on the surface of the slabs, belongs to this zone.

The Zone of Ammonites oxynotus contains three or four species of *Ammonites* which have a very limited range in time, as *Ammonites oxynotus*, *Am. bifer*, and *Am. lacunatus*; with a number of small *Conchifera* belonging to the genera *Arca*, *Leda*, *Astarte*; and small Urchins, as *Acrosalenia minuta*, and fragments of Crinoids.

The Zone of Ammonites raricostatus possesses a remarkable assemblage of *Mollusca*. The *Ammonites* are all special to this zone: of these, *Am. raricostatus*, *Am. armatus*, *Am. densinodus*, *Am. nodulosus*, and *Am. Guibalianus* are the most abundant. *Cardinia Listeri* is found in great numbers, with *Gryphæa obliquata* and *Hippopodium ponderosum*, together with a thin band of small Corals, and *Belemnites acutus*. The clays forming this zone and that of *Am. oxynotus* are largely charged with the sulphuret of iron, and likewise with the peroxides of that metal, so much so that the fine fossils found therein fall to pieces in the bed, or rapidly decompose when exposed to the atmosphere.

The following Table shows at one view the geographical distribution of the different zones of the Lower Lias.

TABLE SHOWING THE ZONES OF THE LOWER LIAS.

		COUNTIES	Gloucester.	Warwick.	Somerset.	Dorset.	Glamorgan.
Clay with *Ammonites Jamesoni*, Sow.							
Ammonitiferous Beds.	Zone of *Ammonites raricostatus.*	*a.* Dark clays and shales, often ferruginous, containing *Hippopodium ponderosum*, *Gryphæa obliqua*, *Cardinia Listeri*, *Thecocyathus rugosus*, *Am. raricostatus*, *Am. armatus*, and *Am. densinodus*..............	*	*	...	*	
	Zone of *Am. oxynotus.*	*b.* Dark clays and shales, much impregnated with iron, containing *Ammonites oxynotus*, *Am. bifer*, *Am. lacunatus*, and *Acrosalenia minuta*..............................	*	*	...	*	
	Zone of *Am. obtusus.*	*c.* Greyish argillaceous limestone, in thin beds alternating with beds of clay and marl, and containing *Ammonites obtusus*, *Am. Birchii*, and *Am. Dudressieri*	*	*	...	*	
	Zone of *Am. Turneri.*	*d.* Hard, dark, slaty clays, or light-coloured shelly limestone, with *Cardinia ovalis*, *Pentacrinus tuberculatus*, *Ammonites Turneri*, *Am. semicostatus*, and Saurians......	*	*	...	*	*
	Zone of *Am. Bucklandi.*	*e.* Bluish-grey limestones, with beds of clay, containing *Lima antiqua*, *L. gigantea*, *Ammonites angulatus*, *Am. Bucklandi*, *Am. Conybeari*, and *Am. rotiformis*	*	*	*	*	*
	Zone of *Am. planorbis.*	*f.* Greyish or light-coloured limestones, in thin beds, interstratified with finely laminated shales; the limestones forming the Paving-beds of Warwickshire and the White Lias of Dorsetshire; and containing *Ammonites planorbis*, *Am. Johnstoni*, *Lima punctata*, *L. gigantea*, *L. pectinoides*, *Hemipedina Tomesii*, and spines of *Cidaris*......................................	*	*	*	*	*
Non-Ammonitiferous Beds.	Ostrea Beds.	*g.* Hard dark-grey limestone, containing *Ostrea liassica* in great abundance, with skeletons of *Plesiosaurus megacephalus*, *P. Hawkinsii*, *Ichthyosaurus intermedius*, and *I. tenuirostris*	*	*	*	*	*
	Zone of *Avicula contorta.*	*h.* Dark shales, with thin bands of limestone, often pyritic, and thin beds of light-coloured micaceous sandstone, with a thin band of bone-breccia near the base. These contain *Avicula contorta*, *Pecten Valoniensis*, and *Pullastra arenicola*.......	*	*	*	*	*
Red Marls of the Keuper.							

In concluding these observations on the different zones of the Lower Lias, I would remark that nearly all the species contained in these beds differ from the species of the Middle Lias, which, in like manner, can be divided into several distinct zones by the *Ammonites* contained in them. I must reserve my observations on this subject to a future communication, in which I propose giving a table showing the stratigraphical distribution of all the *Invertebrata* of the Lias.

March 14, 1860.

The Rev. T. G. Bonney, M.A., Fellow of St. John's College, Cambridge, and the Rev. Henry Eley, M.A., Broomfield Vicarage, Chelmsford, were elected Fellows.

The following communications were read :—

1. *On the occurrence of* Lingula Credneri, Geinitz, *in the* Coal-measures *of* Durham; *and on the Claim of the* Permian Rocks *to be entitled a* System. By J. W. Kirkby, Esq.

[Communicated by T. Davidson, Esq., F.G.S.]

The recurrence of Carboniferous species in Permian strata is not new to palæontologists; for recurrent species from the Carboniferous fauna, and such as were supposed to be recurrent, have been noticed by several observers. Messrs. Lonsdale*, Jones†, Howse‡, King§, and Davidson‖, as well as others, have identified Permian with Carboniferous species, or *vice versâ*, though it may be remarked that in some cases their determinations have been undoubtedly erroneous.

The discovery of another species which had long been thought characteristic of the Permian period, in Carboniferous strata, is therefore not so novel a fact as might appear at first sight. At the same time, I deem it well to record its occurrence, which is not without importance. It is of interest merely as the discovery of another species which is common to the faunæ of the two later palæozoic eras; and it is of consequence as a fact which assists in illustrating some of the physical conditions which prevailed during the deposition of the Upper Coal-measures of the North of England.

In the Permian formation, *Lingula Credneri* is confined to the lower strata. In England it is restricted to the "Marl-slate," and the lower beds of the "Compact Limestone. It is not common in these members, having been found only at Ferry Hill, Thrislington, and Thickley.

As a Carboniferous shell it only occurred to me during the summer of last year (1858), at the Ryhope Winning, near Sunderland. I first observed it in a thin bed of dark shale, at a depth of 951 feet from the surface, or 592 feet from the base of the overlying Permian strata. In this bed it was exceedingly rare; but I found it more plentiful in a thick stratum of grey shale just above the bed already mentioned.

From the first I was struck with the resemblance of these *Lingulæ* to the Permian species *L. Credneri*; and my opinion was only

* Lonsdale on Corals, in 'Silurian System' (*Fenestella antiqua*).

† Jones on Entomostraca, in Prof. King's Mon. Perm. Foss. pp. 61, 62 (*Cythere* [*Bairdia*] *curta*, &c.).

‡ Cat. of Fossils in Perm. Syst. of Northumb. and Durh. p. 40 (*Spirorbis globosus*).

§ Cat. Org. Rem. of Perm. Syst. p. 13 (*Loxonema rugifera*); see also Mon. Perm. Foss. p. 150 (*Terebratula sufflata*).

‖ Mon. Carb. Brachiopoda, pp. 14, 38 & 58 (*Terebratula Sacculus*, &c.); also in 'Geologist,' vol. iii. pp. 19 & 21.

strengthened by the acquisition of a full suite of specimens. Not to rely solely upon my own judgment, however, I have submitted some of the finest examples to the inspection of Messrs. R. Howse, A. Hancock, and T. Davidson, who quite agree in referring them to *L. Credneri*.

There is no essential difference between the Permian and Carboniferous specimens. The form of both is nearly oval. Each show similar slight modifications of outline—occasionally becoming somewhat oblong, and having the posterior end more acuminate. The lines of increment are alike in both; and there is no difference in the thickness of the shell, which in both cases is extremely delicate. The Carboniferous specimens have the median elevation more prominent than those from the marl-slate; but in this respect they only approach more closely to the Permian examples from the Kupfer-Schiefer, the German equivalent of the Marl-slate. In no respect do the Permian differ from the Carboniferous specimens more widely than do individuals of the same series from each other.

The intervening space between the Marl-slate and the Lingula-shale at Ryhope is 680 feet: 96 feet of this is occupied by the Rothliegende, or Lower Red Sandstone, which, with Murchison and others, I consider to be Permian*; the rest is true Coal-measures, and includes seventy-one changes of strata. The predominating mineral character of the latter is argillaceous; the arenaceous and carbonaceous beds occupy less than a third of the whole. Twelve seams of coal are included in these strata, the most being unworkable; they give an aggregate thickness of 8 feet 2 inches. With one exception, these coal-seams appear to have resulted from growth on the spot; for in eleven instances they rest upon "thill"—a term of the Durham miners for the underclays containing *Stigmariæ*, which are now generally supposed to have been the soils of the Carboniferous forests. In one instance a seam, 13 inches thick, rests upon a white sandstone, in which case the coal may be the result of vegetable drift†. These facts seem to indicate that, even as a Carboniferous species, *Lingula Credneri* enjoyed a range in time of no mean length;

* Some geologists refer the Rothliegende, or Lower Red Sandstone, to the Coal-measures. Mr. Howse quotes its conformability to, and the identity of its fossils with those of the Coal-measures as sufficient evidence for classing it with the latter strata. On the other hand, it is contended by Sir Roderick Murchison that a more comprehensive view leads to the conclusion that it belongs to the Permian group. The question is of some interest; and I would refer those who wish for further information to Mr. Howse's paper in 'Annals and Mag. Nat. Hist.' 2nd ser. vol. xix. pp. 37 & 38; and to 'Siluria,' 2nd edit. p. 347.

† In the majority of cases, when coal rests upon sandstone, I believe this surmise to be correct. But I have observed *Stigmaria ficoides*, Brongn., in white argillaceous sandstone, with its rootlets well preserved, and apparently in their original position. In this instance the *Sigillaria* may possibly have grown on a sandy soil; or its roots (*Stigmaria*) may have penetrated through a more suitable but thin soil, into an arenaceous stratum below. As a rule, however, it is not unlikely that seams of coal resting upon sandstone may be the result of vegetable drift.

I am informed by a friend, that in the coal-field of the Forest of Wyre, *Stigmaria*, with the rootlets in position, occurs in white fine-grained sandstone, beneath a seam of imperfect coal.

for it is difficult to suppose that all these alternations of strata, and the growth and accumulation of twelve distinct stages of vegetable matter, could be otherwise than slowly effected. Comparatively speaking, however, and so far as we know, its advent was towards the close of the Carboniferous period.

In the stratum of shale in which the first *Lingulæ* were found, there occur the remains of Fish, Entomostracans, and Plants, as well as those of a species of *Anthracosia*, which are very numerous on one horizon of the bed*. The piscine remains consist of Ganoid scales, some of which are beautifully coated with brown enamel; Sauroid teeth resembling those of *Holoptychius Hibberti*; and spines and isolated bones. These remains are always in a detached state,—the scales never being connected, nor the bones in juxtaposition. The *Entomostraca* belong to two species, one of them bearing some similarity to *Cypris inflata*, Murchison. The association of *Entomostraca* with Fishes may, perhaps, assist in explaining the fragmentary condition of the latter, as has been suggested before in a similar instance. Among the vegetables is a small species of *Lepidodendron*, and apparently a *Sigillaria* and a *Calamites*. On one horizon of the stratum, the vegetable matter seems to form a layer of bituminous coal; and it is in this that the fish-remains are the most numerous. The *Mollusca* and *Entomostraca* are not found in the coal, but only where the stratum is more argillaceous. The *Lingulæ* and *Anthracosiæ*, though in the same stratum, are not associated. The remains of *Fishes* are in close contiguity with the former; and sometimes all the remains, *Lingulæ* excepted, are to be seen on one plane, as though individuals of the different species had lived and died together. In the grey and more argillaceous shale above the first-mentioned bed, and where the *Lingulæ* are more common, the only other remains which occur are a few Ganoid scales and bones of *Fishes*.

It is not my intention at present to enlarge on the peculiar character of this assemblage of species, further than to notice how the occurrence of the *Lingulæ* establishes the fact that marine conditions must occasionally have prevailed in the Durham area during the accumulation of the Upper Coal-measures. The discovery of *L. Credneri* (an unquestionably marine shell) is, I believe, the first indication of marine conditions in this coal-field. Hitherto the Durham Coal-measures have always been referred to as a series of freshwater strata†, and pre-eminently lacustrine. It is therefore well we should know that, though the general character of these measures is decidedly lacustrine, or, rather, fluviatile, yet that in rare instances there are intercalations of strata which contain marine remains.

In commencing these remarks, the existence of other Carboniferous species common to Permian rocks was generally alluded to. It may

* I am informed by Mr. G. Tate, F.G.S., that in the mountain-limestone there is a similar group of organisms in a shale connected with a coal-seam at Brunton in Northumberland, where there are *Lingula squamiformis*, *Entomostraca*, *Anthracosia*, remains of Ganoid Fish, and Plants.

† See Lyell's 'Elements of Geology,' 4th edit. pp. 325, 326; and Phillips in Encyc. Metrop., art. "Geology," p. 592.

not be out of place to mention those species which are now allowed to be common to the Carboniferous and Permian faunæ.

Through the critical and most elaborate researches of Mr. Thomas Davidson, several of the Permian *Brachiopoda* have been proved to be recurrents from the Carboniferous fauna. Some of these had long been suspected by other palæontologists to be very closely related to, if not identical with, Carboniferous species*. In his Monograph of the Carboniferous Brachiopoda, Part I., Mr. Davidson has already shown the identity of the Permian species *Terebratula sufflata*, *Spirifera Clannyana*, and *Spiriferina cristata* with the Carboniferous species *T. Sacculus*, *S. Urii*, and *S. octoplicata*; and in the forthcoming Part of that valuable work, it will be seen that there are also two other Brachiopods in Carboniferous rocks which are essentially the same as species occurring in the Permian strata of Durham†. By the courtesy of Mr. Davidson, I am allowed to mention that these species are *Camarophoria crumena* and *C. rhomboidea*, which are identical with the Permian species *C. Schlotheimi* and *C. globulina*. It is also the opinion of Mr. T. Rupert Jones that three species of Permian *Entomostraca* are identical with the Carboniferous species *Cythere elongata*, *C. inornata*, and *C.* (*Bairdia*) *gracilis*‡. These determinations are certainly not so conclusive as those of the *Brachiopoda*, as the comparative examination which the species have undergone has not been so rigorous, owing to the greater scarcity of specimens; but, so far as may be judged from the existing materials, it is the opinion of Mr. Jones that the Permian specimens belong to the species to which he refers them.

And in regard to the flora of the British Rothliegende, the species either appear to be identical with such as occur in the Coal-measures, or to belong to genera characteristic of these strata. The researches of Mr. Howse in the Rothliegende, or Lower Red Sandstone, at Tynemouth, resulted in the discovery of *Pinites Brandlingi*, *Trigonocarpum Nœggerathi*, *Sigillaria reniformis*, *Calamites approximatus*, and *C. inæqualis?*, all of which are found in the Coal-measures§. *Gyracanthus formosus*, a Carboniferous *Placoidean*, also occurs in this deposit.

To recapitulate, the following species appear to be common to both Carboniferous and Permian strata. The names marked with asterisks have the right of priority.

Carboniferous Name.	Permian Name.
1. **Terebratula saccultus*, Martin, 1809. *Conchyliolithus Anomites Sacculus*, Martin, Petrif. Derbiensia, pl. 46,	*T. sufflata*, Schloth., 1816, Denksch. Akad. Münch. vol. vi. pl. 7. fig. 10.

* See Prof. King's remarks on *Terebratula sufflata*, Mon. Perm. Foss. p. 150, also in the Introduction, p. xxv.

† See also in 'Geologist,' vol. iii. p. 19 note, and p. 21.

‡ See Jones in King's Mon. Perm. Foss. pp. 62 & 63; also Jones and Kirkby on Permian Entomostraca in Trans. Tynes. Nat. Field-Club, vol. iv. p. 122.

§ Howse, "on Perm. Syst. of Northumb. and Durh.," Ann. and Mag. Nat. Hist. 2nd ser. vol. xix. p. 38; also Trans. Tynes. Nat. Field Club, vol. iii. p. 239.

Carboniferous Name.	Permian Name.
figs. 1 & 2; Davidson's Carb. Brach. p. 14, pl. 1. figs. 23, 24, 27, 29, 30.	
2. **Spirifera Urii*, Fleming, 1828. *Sp. Urii*, Flem. Hist. of British Anim. p. 376; and Dav. Carb. Brach. p. 58, pl. 12. figs. 13, 14.	*Martinia Clannyana*, King, 1848, Cat. of Organ. Rem. Aug. 19th, 1848; and Mon. Eng. Perm. Foss. p. 134, pl. 10. figs. 11–13.
3. *Spiriferina octoplicata*, J. de C. Sowerby, 1827, Min. Con. p. 120, pl. 562. figs. 2–4; and Dav. Carb. Brach. p. 31, pl. 7. figs. 37–47.	**Sp. cristata*, Schloth., 1816. *Sp. cristata*, Sch. Beitr. z. Naturg. d. Verst. in Akad. der Wissensch. zu München, pl. 1. fig. 3.
4. **Camarophoria Crumena*, Martin, 1809. *Conchyliolithus Anomites Crumena*, Martin, Petrif. Derb. pl. 36. fig. 4.	*Terebratula Schlotheimi*, Von Buch, 1834, Ueber Terebrateln, p. 37, pl. 11, fig. 32.
5. *Terebratula rhomboidea*, Phillips, 1836, Geol. of York, vol. ii. pl. 12. figs. 18–28.	**Camarophoria globulina*, Phillips, 1834. *T. globulina*, Phillips, Ency. Met. (Geology) vol. iv. pl. 3. fig. 3.
6.	**Lingula Credneri*, Geinitz, 1848, Versteinerungen des Zechst. p. 11, pl. 4. figs. 23–29.
7. *Cythere elongata*, Münster, 1830, Jahrbuch f. Min. p. 65. n. 19.	*C. elongata*, Mün., Jones in King's Mon. Perm. Foss. p. 62, pl. 18. fig. 5; and Jones on Perm. Entom. in Trans. Tynes. Field-Club, vol. iv. p. 159, pl. 11. fig. 2.
8. *Cythere inornata*, M'Coy, 1844, Syn. Char. Carb. Foss. p. 167, pl. 23. fig. 18.	*C. inornata*, M'Coy, Jones in King's Mon. Perm. Foss. p. 63, pl. 18. fig. 9; and Jones on Perm. Entom. in Trans. Tynes. Nat. Field-Club, vol. iv. p. 160, pl. 11. fig. 6.
9. *Bairdia gracilis*, M'Coy, 1844, Syn. Char. Carb. Foss. p. 165, pl. 23. fig. 7.	*Cythere* (*Bairdia*) *gracilis*, M'Coy, Jones in King's Mon. Perm. Foss. p. 62, pl. 18. fig. 7; and Jones on Perm. Entom. in Trans. Tynes. Nat. Field-Club, vol. iv. p. 163, pl. 11. fig. 15.
10. *Gyracanthus formosus*, Agassiz, Poissons Fossiles, vol. iii. p. 17, pl. 5. figs. 4–8.	*G. formosus*, Ag., King's Cat. Org. Rem. p. 14; and Mon. Perm. Foss. p. 221; also Howse in Trans. Tynes. Nat. Field-Club, vol. iii. p. 239.
11. *Pinites Brandlingi*, Lindley. 12. *Trigonocarpon Nœggerathi*, Br. 13. *Sigillaria reniformis*, Brongn. 14. *Calamites approximatus*, Brngn. 15. —— *inæqualis* (?), Lindley.	See Howse on Perm. Syst. of Northumb. and Durh. in Trans. Tynes. Nat. Field-Club, vol. iii. p. 239.

In this list of species common to the Carboniferous and Permian rocks, I have only included those which have been pronounced recurrents by careful palæontologists. There are other species which appear to be such, but which as yet have not been proved to be identical with the Carboniferous forms which they resemble. Among the most prominent is a Polyzoon called *Fenestella retiformis* by Permian palæontologists, which bears so strong a resemblance to a species in the Mountain Limestone (namely, *Retepora membranacea*) that I almost believe them to be the same; but as I have not yet been able to examine a good celluliferous face of the Carboniferous species, I cannot decide whether they are identical or not.

It is not unlikely that some geologists may question the authenticity of the identifications already made; for there are those who hold

that no species ranges beyond its own system of strata—beyond the system in which it first appears*. But if there be any veracity in palæontology, it establishes the fact that species are not confined to systems of strata†. So, if we even assume that the Permian rocks form as sound a system as the Silurian, there are still no reasons for denying upon principle the identifications made. The rules applied to the determination of these species are those which are used in the determination of species belonging to one system. The same principles which are followed in resolving a fauna or flora into species ought to guide palæontologists in their more comprehensive studies of the life-groups of adjoining systems; and these I believe to be the principles which have controlled the decisions of Messrs. Davidson, Howse, and Jones in the determination of these recurrent species. Of course the possibility of error is not denied; but so far as the existing materials supply information, their conclusions appear to be legitimate, and the only ones at which they could philosophically arrive.

From the preceding list of Carboniferous species found also in the Permian strata of Durham, we are able to see at a glance the specific relationship (so far as at present known) which exists between the life-groups of the later palæozoic periods. The generic affinity of these groups has long been noticed. The latter feature, and other apparent indications of the absence of a systematic difference, have originated a proposal that the Permian strata should be included in the Carboniferous system; and it is not to be denied that the existence of so many Carboniferous recurrents in the Permian fauna and flora lends support to the suggestion. In admitting thus much, I have no wish to abandon the term "Permian" as the distinctive title of those rocks which now rank under that name; but I certainly do doubt whether they ought to be classed as a distinct *system*.

There appears to be a general want of importance about the Permian rocks as a group, that is opposed to their classification as a separate system. They possess not the vertical range of other systems of strata. Their life-groups are chiefly based upon Carboniferous types; and the development of species is exceedingly meagre compared with species-development in other systems. Consequently there appear to be no reasons for considering that they represent a period of ancient time that possesses anything like equivalency of value to the periods which other palæozoic systems apparently indicate. It is true, certainly, that the bulk of the Permian species are distinct; but it is just as true that 15 recurrent Carboniferous species, in the comparatively small fauna and flora of Britain, form a much greater percentage than recurrent species usually occupy in the faunæ and floræ of other systems; indeed the percentage is much greater than that which obtains in some of the subdivisions of the Silurian

* See Bigsby on Palæozoic Rocks of New York, in Quart. Journ. Geol. Soc. vol. xv. p. 289, where Angelin, Pictet, D'Orbigny, and Agassiz are quoted as being of this opinion.

† See some interesting remarks on recurrency by Dr. Bigsby in Quart. Journ. Geol. Soc. vol. xv. p. 288–292.

system. As an instance, I may refer to the Trenton Limestone of the palæozoic basin of New York, which contains 250 species, only 6 of which are received from underlying strata*. On the most liberal estimate, the Permian species of Britain do not form so large an aggregate; and on an estimate which appears more in harmony with truth, they only number 136 species†. It will be seen, therefore, that Carboniferous recurrents form about 11 per cent. of the British Permian species. As yet, nothing is known of the recurrency of Carboniferous species in the Permian faunæ of Germany and Russia. It may be that these faunæ contain no recurrents from an earlier era, in which case the general percentage of such recurrents in the Permian fauna at large may not appear so great; but from analogy we should imagine otherwise. Our knowledge of the Russian fauna can at the best be but elementary; and we may rest assured that, notwithstanding the valuable researches of Sir Roderick Murchison and his coadjutors in Perm, there cannot but remain a large mass of information to work out. It is possible to get more or less correct ideas of a life-group by a cursory examination of the rocks containing it; but to acquire a full and complete knowledge demands long-continued researches‡, for such a knowledge is the aggregate of a multiplicity of details which can only be collected by years of observation.

In respect to the appearance of new generic types during the Permian period, I may add that the only genera of *Mollusca* which are apparently met with for the first time are *Myoconcha* and *Thecidium*, which are likewise accompanied by the subgenera *Monotis* and *Aulosteges*: the rest of the *Mollusca* belong to genera which appear earlier. A genus of *Crustacea* (*Palæocrangon*) appears for the first time, and, so far as is known, the only time. The *Polyzoa*§, *Echinodermata*, *Zoophyta*, and *Rhizopoda* are all of Carboniferous or more ancient genera. It seems questionable whether any new generic forms of Fish appear during Permian time; certainly none in Britain. Indeed the only class of animal life that assumes generic characters which appear to be peculiarly Permian are the *Reptilia*. Some stress has been attached to the specific distinction of the Permian flora in Germany from that in Britain; and attention has been drawn to the

* Quart. Journ. Geol. Soc. vol. xiv. pp. 344 & 345, also table, p. 420.

† In this estimate of the Permian fauna and flora as distributed in Britain, the number of species in each class are as follows: *Reptilia* 3, *Pisces* 17, *Cephalopodon* 1, *Gasteropoda* 20, *Conchifera* 20, *Pteropodon* 1, *Brachiopoda* 17, *Polyzoa* 7, *Crustacea* 22, *Annelida* 4, *Echinodermata* 2, *Zoophyta* 2, *Amorphozoa* 5, *Rhizopoda* 5. Between this enumeration and one based on the views of Prof. King, there would be a difference of about 30 species,—the latter authority regarding as species about 30 forms which I believe to be only varieties at the most.

‡ It is not, of course, assumed that we can ever attain a *full* and *perfect* acquaintance with any ancient fauna or flora, but only so far as its remains have been preserved, and so far as it may be possible to examine them. In this sense our knowledge of one fauna may be full and complete, owing to more elaborate researches, in comparison to what we know of another fauna which has not been so well investigated.

§ It was supposed by Prof. King (Mon. Perm. Foss. p. xix) that his genus *Synocladia* was confined to the Permian rocks; but a Polyzoan occurs in the Mountain Limestone of Settle, which undoubtedly belongs to the same group.

genus *Psaronites* as being particularly distinctive of the Rothliegende. From the slight acquaintance I possess with this flora, I am not aware that it differs generically from the preceding flora of the Coal-measures; and with respect to *Psaronites*, it is undoubtedly a Carboniferous genus, having occurred in the coal-fields of France and the United States*. It is for those who have studied palæozoic rocks and organic remains to decide whether so subordinate a development of generic types can be compatible with the systematic distinction of the Permian strata.

It is undoubtedly difficult to define the precise amount of value attached to the term "system"; and perhaps it is not to be expected that perfect uniformity of value can be adhered to in systematic groups of strata; still it is highly desirable to approximate to this for sound classification. At any rate it seems practicable to observe a greater degree of consistency in the division of the palæozoic strata into primary groups than exists in the quaternary system now adopted. For, if we are to consider the whole of the Silurian rocks and the various phenomena they express as only sufficient to constitute one system, upon what principles of classification are we to grant the same value to the Permian rocks, the importance of which in every respect is less than that of either the Upper or Lower Silurian groups? If the one merely suffice to establish a system, surely the other must fall greatly short. Or if the latter suffice, does not the former more than suffice?

It may be contended that magnitude is not the only element in constituting systems, nor yet, perhaps, the character of organic remains, but that conformability, or the converse, is of more importance than either, or both. Now it scarcely comes within the scope of this paper to discuss the merits of the Permian system in this light. My remarks are based on the palæontological aspects of the question, which I hold to be of infinitely greater consequence in the grouping of strata than the relative position which strata occupy. Conformability of strata does not prove that they were deposited with regularity, or that they do not belong to widely separated periods of time; nor does unconformability demonstrate the close of one period and the commencement of another; for it has yet to be proved that a general disturbance of strata ever took place—that unconformability is ever more than local. I therefore maintain that it is chiefly upon life-phenomena that we must rely in the classification of rocks, and that, in all attempts to arrive at an approximation to the relative value of ancient periods of time, the evidence afforded by organic remains must be of greater importance than that of the rocks containing the remains.

In thus attempting to show the close relationship that exists between the Permian and Carboniferous life-groups, I speak only according to the present state of palæontology. The later advances of this science seem to tend towards the abrogation of all natural systems; and it is not unlikely that ultimately geologists and palæontologists will have to admit, as some perhaps admit now, that all

* Lyell's Elements of Geology, 4th edit. p. 307.

classifications of rocks must be artificial. Therefore, in arguing for the close affinity of these life-groups, I have no intention of maintaining that even the two united indicate a natural and distinct group or system. In some respects the Permian fauna is related to that of the Triassic period; but this relationship appears to be more remote than that with the Carboniferous, though perhaps less than is generally supposed. All that I wish and try to prove is, the comparatively intimate connexion which exists between life-groups of the two periods—a connexion which seems to be more intimate than that existing between the Silurian and Devonian, or between the Devonian and Carboniferous systems, so far as is yet known. At the same time I do not deny the probability that the palæontogical connexion between these systems may at last be found to be much closer than now; for I would rather refer all sudden changes in the distribution of fossil species to breaks in the continuity of preservatory agencies than to breaks in the continuity of ancient existences.

In conclusion, I must add that in making these somewhat cursory remarks I have no intention of speaking authoritatively, or without due respect to those who hold different opinions. The sentiments expressed are certainly based on the results of several years' researches in Permian palæontology; but still they are merely those of a student, not of a professor.

P.S. Since writing the preceding remarks, I have had the opportunity (through the kindness of Mr. Davidson) of reading a paper by M. Marcou, entitled "Dyas and Trias; or, the New Red Sandstone in Europe, North America, and India," in which an attempt is made to prove that the Permian strata should not be classed as a palæozoic formation at all, but rather with the New Red Sandstone as mesozoic. In this paper M. Marcou maintains that the Permian formation has been classed with other palæozoic groups solely on the strength of the *facies* of its Molluscs and Plants. On this point I may be allowed to remark that the facies of the whole of its fauna, as well as those of its flora, are in favour of such a classification. And though M. Marcou has quoted the *Vertebrata* and *Crustacea* as being corroborative of his views, yet when we remember that the bulk of the Vertebrates belong to genera so pre-eminently palæozoic as *Palæoniscus*, *Acrolepis*, *Pygopterus*, *Cœlacanthus*, and *Gyracanthus*, and that, with one exception, the Crustaceans belong to genera which existed in præ-Permian eras, and that among them is a genus of *Entomostraca* (*Kirkbya*) which is intimately related to *Beyrichia*, besides a Trilobite of the genus *Phillipsia*, it is difficult to see where the corroboration lies. But, without going into further details, it may, I think, safely be said that the *facies* of the Permian fauna is decidedly palæozoic—that, besides generic types so palæozoic as *Productus*, *Strophalosia*, *Aulosteges*, *Spirifera*, *Streptorhynchus*, *Athyris*, *Cardiomorpha*, *Orthoceras**, *Bellerophon**, *Conularia* among the *Mollusca*, there are *Fenestella*, *Synocladia*, *Cyathocrinus*, *Kirkbya*, *Phillipsia**,

* Those genera marked with asterisks have been added to the Permian fauna by the researches of American palæontologists in New Mexico and Texas.

Palæoniscus, &c., among the other classes, the *facies* of which is equally antique.

M. Marcou does not, however, rely altogether upon the argument just noticed for the support of his views; he advances another, which I believe to be equally erroneous. Apparently under the impression that the Permian strata should be referred to the Trias on account of their lithological and mineralogical relationship, he maintains, after depreciating the importance of palæontological evidence, that the *ensemble* of the purely geological characters of a group of strata is of the chief consequence, and suffices alone to determine the age and relative position of the group in any part of the world. Now, as M. Marcou has specialized the Carboniferous and Cretaceous systems as being highly illustrative of the truth of this, I would ask, how we could have determined the age of the Cretaceous rocks of the United States if we had not been assisted by palæontology?—and who could have told us the age of the Virginian Coal-field, which is described by Sir C. Lyell as being composed of "grits, sandstones, and shales exactly resembling those of older or primary date in America and Europe, and even rivaling the latter in the thickness of its coal-seams," if we could not have availed ourselves of palæontological tests? And if we refer to the investigations of Dr. Geinitz on the Coal-measures of Saxony, we find that by palæontological evidence he has been able to separate a Permian deposit from those truly Carboniferous, and also to show good reasons for supposing the lowermost coal-strata of the same country to be of Devonian age. Other instances are to be found in formations of all periods. In arguing for the superior importance of palæontological evidence, I do not, as I have before stated, deny the value of other evidence (indeed, it is highly requisite that all characters should be consulted in settling the age of strata), but I argue against coming back to the old doctrine of the universality of deposition of one kind of sediment during certain periods; for the study of organic remains has proved its unsoundness.

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2. *On the* Rocks, Ores, *and other* Minerals *on the Property of the* Marquess of Breadalbane *in the* Highlands *of* Scotland. By C. H. Gustav Thost, Esq.

[Communicated by Prof. James Nicol, F.G.S.]

[Abridged.]

Mica-schists, &c.—On the property of the Marquess of Breadalbane (measuring in a curve nearly 100 miles from east to west, through Perthshire and Argyllshire) mica-schist predominates. The high mountains (Ben More, Ben Lawers, and others) forming the nucleus of the Grampians consist of the same rock, which throughout the property exhibits its many varieties of mineral character, and includes talc-schists, chloritic schist, and hornblende-rocks, often to a great extent. In juxtaposition to the mica-schist, in the northern

and north-western part of the district, gneiss and granite appear. Among the more useful subordinate rocks is a calcareous variety of the mica-schist (limestone), in beds and in lenticular masses, containing as much as 90 per cent. of carbonate of lime. Another stratified rock found in close connexion with the mica-schist is clay-slate, lying on the north side of Ben Lawers, and at a great elevation. The difficulty of access is the only cause why it is only rarely used as roofing-slate. These subordinate strata participate in most cases in the general bearing of the mica-schist, which is nearly east and west; while the dip of the mica-schist, though in general low, appears as often exceptional as conformed to rule. While in special cases the underlie surrounds the several axes of elevation, sloping from them on all sides, both the strike and dip are not unfrequently altered by the appearance of eruptive rocks and other disturbing masses, as, for instance, by intersecting veins and ridges of quartz. The latter mineral in general seems to have played a considerable part in metamorphosing and silicifying the adjacent mica-schist, having in many instances made its appearance after the formation of the mica-schist. Although those disturbing causes have exercised a great influence upon the original beds of the rock, as may often and very clearly be observed, they nevertheless leave sufficient traces of the strata having had originally a horizontal position.

Tomnadashan Mines.—Among the igneous rocks, porphyries and greenstones deserve particular notice, on account of their frequency throughout the district. As a special case, probably illustrating all the others, the rocks near the middle of the south side of Loch Tay, opposite Ben Lawers, at the Tomnadashan Mines, invite close inspection; for in that place mining-operations have extensively aided observation. All the facts there obtained support the supposition, that, after the mica-schist had been broken through by the greenstone, a powerful vein of porphyry was erupted; for the greenstone, while remaining unchanged in position and character on the east and west sides of the porphyry-vein, has near its middle part not only been deranged by mechanical force, but has also been often altered by chemical agency into a substance exhibiting the mixed characters of greenstone and porphyry, with transitions from one to the other. It is not difficult to arrive at a probable estimate of the period when the mineral ingredients—silver-ore, copper-pyrites, grey copper-ore, iron-pyrites, and molybdenite—have made their appearance, if the porphyry be considered as the matrix; for, while the porphyry-vein, although about half a mile wide, and extending about three miles towards the south, is nowhere destitute of one or other of the above-named minerals (particularly iron-pyrites), the greenstone, when in its original condition, nowhere contains a trace of those substances. The only question remaining would be, whether those ores belong to a later formation than the porphyry itself, or whether they are contemporaneous deposits. The general dissemination of these minerals through the porphyry appears to prove the latter view. Closer inspection shows that the greenstone exercised a particular influence upon the deposition and accumulation of the minerals named, which

not seldom, and in marked richness, surround fragments of the greenstone. This probably arose from the fluid mass cooling sooner in these places, so that the metallic minerals suspended in the porphyry adhered to and fastened themselves in greater abundance on and near the cooler surfaces of the broken greenstone; whilst the main stream of the porphyry, loaded with the same minerals, continued its way, and both rock and mineral particles had to harden together. During this process the particles of ore easily penetrated the smallest crevices of the greenstone, where they soon cooled down and solidified, as can be observed on innumerable specimens, and in many varieties.

Not only has the greenstone partaken, partly at least, of a change as regards its absolute situation and its chemical composition, but parts also of the mica-schist, though to a less extent and less frequently.

If mica-schist came in contact with the porphyry, the formation of slickenslides or surfaces of friction took place. In the mines of Tomnadashan several such divisions, which have received the general name of "clay-veins," may be seen, forming very regular courses both in perpendicular and horizontal directions. They are of some importance to the miner, because they are leaders through the hardness of the rock to be opened, and they are receptacles of the more valuable minerals, in the same way as the greenstone.

Besides the above-mentioned metallic ores, carbonate of lime, in scalenohedron-macles and in other crystallographic combinations, as well as dolomite, quartz, and sometimes sulphate of baryta, have been found near the richer deposits of ore, especially where the grey copper-ore predominates.

Molybdenite is met with as an accessory mineral everywhere. In all other respects the valuable minerals are deposited apparently in a casual arrangement.

Relation of the Valleys to the lines of fracture.—The same rocks, greenstone and porphyry, appear in many other localities of the valley of Loch Tay; and there is little doubt that to these igneous masses the formation of the now water-covered valley itself is attributable. The same conclusion may be drawn in reference to Loch Awe, Loch Tulla, and Loch Etive, in the western and northwestern part of the district, where, however, granites and granitic porphyries have produced the same results that the greenstones and porphyries have effected at Loch Tay. It is thus probable also that very many valleys have received their forms from similar agencies. It is a remarkable fact, that the highest points of the Highlands, like Ben Lawers, Ben More, Ben Nevis, Ben Lomond, Ben Conachan, and many others of less height, have at their feet the deepest valleys, which have become lakes.

Ardtallanaig.—At Ardtallanaig, only a mile distant from the above-mentioned mines, similar geological features reappear; and the mica-schist has been repeatedly intersected by igneous rocks, thereby rending asunder a vein or veins, and intermixing the fragments from different masses, so that the constituent members have

been thrown into perfect confusion. Hence the veins throughout have a fragmentary character; and the portions remaining give proof that they originally contained, besides quartz, several kinds of the common spars (particularly heavy-spar), together with a considerable admixture of galena, blende, and copper, and iron-pyrites. Moreover they either frequently contain porphyry and greenstone, or these rocks have intruded as disturbers of the veins. Mining-operations in such broken strata are very precarious.

Correbuichill.—In a southern direction, ascending from the Tomnadashan Mines, and at a distance of about three miles, the mica-schist at Correbuichill is overlain by a horizontal calcareous stratum. In this rock two systems of veins have been discovered, chiefly by means of surface-trenches. The one system, consisting of three veins which run nearly east and west, is of small importance, on account of their barrenness. But the other is the more interesting system. In a straight line of about 200 yards, eighteen such veins have been met with; and it is more than probable that a far greater number remain undiscovered under the shallow turf. These veins have almost a mathematical parallelism, and run as nearly as possible due north and south, in nearly a vertical position. Their width varies from 4 inches to 3 feet. The contents are chiefly quartz, with galena very rich in silver. The veins vary as to this valuable metal, between 85 and 600 ounces per ton of lead-ore. The elevation of the hill may be about 2000 feet above the level of the sea, and 1600 feet above that of Loch Tay. The veins mostly crop out in fine gossan; and in such cases the produce of ore has been favourable for a certain distance downwards. As far as the field has been opened by mining, experience shows that the valuable lead-ore quickly and considerably diminishes in sinking, so that in about 100 feet below the outcrop the veins only consist of compact white quartz. It has not been ascertained what is the condition of the veins at the depth where the limestone rests upon the mica-schist. In the upper parts of the veins the galena not unfrequently envelopes the crystals of quartz completely, thereby indicating that the galena and quartz are not contemporaneous members. Copper-pyrites is rare, and still more so are blende and iron-pyrites; hence the lead-ore is of a very pure and rich character. In one part of the hill a large deposit of dolomite, in the form of a vein, has been met with, accompanying one of the veins. Twice in the course of mining operations (which some years since were suspended) the interesting and casual discovery of native gold was made when the ore was being crushed under the hammer. The veins have been repeatedly dislocated, both in the horizontal and in the vertical projections. In consequence of this, the veins sometimes approach quite close to each other, and it becomes difficult to discover in the network of veins the identity of each individual vein. The dislocations have been effected by the sliding and uplifting of the strata, which, in the absence of other apparent causes, and as the veins and strata have both been dislocated together, may be ascribed to the disturbances at Tomnadashan, in the neighbourhood. Though mining-operations in such elevated

localities become very incommodious, this mineral field abounds with interesting matter.

Taymouth.—The most eastern hills on Loch Tay, in the neighbourhood of Taymouth, literally swarm with veins containing copper-pyrites, iron-pyrites, and galena, either singly or together; and the lead-ore has always a tolerable admixture of silver. A common characteristic of all the veins is, that they are almost exclusively quartzose.

Iron-ore of Glenqueich.—Six miles south of Taymouth, at Glenqueich, a large deposit of decomposed iron-ore has been found. The whole arrangement of the slope of the hill shows that the mica-schist has been impregnated with numberless crystals of iron-pyrites, which by paragenesis became transformed, along with the still quite distinct strata of the original rock, into a homogeneous mass, having the nearest resemblance to hæmatite.

Corycharmaig: Serpentine, &c.—Four miles west from the upper end of Loch Tay, at Corycharmaig, the mica-schist contains serpentine, passing in some parts into syenite. As is almost always the case where serpentine appears, it contains chromate of iron. The distant situation of this ore-deposit, which covers about half a square mile, the uncertain prices given for the ore, and the expensive land-carriage have prevented the exploration of that otherwise valuable mineral-field.

In the same vicinity the mica in the mica-schist is more often than usual replaced by graphite, of which beds of tolerable dimensions have been discovered. Furthermore, in the same neighbourhood rutile has been found, enveloped in quartz, and in the shape of thin plates or of fine long needles.

Further west from the serpentine, several veins of a quartzy structure have been found; but they are all of small importance for mining-purposes, being only of value as enabling us to observe the great number of fissures existing in almost every place where the rock allows of inspection.

Loch Earn Head.—At Loch Earn Head several galena-veins, of inferior importance, have been discovered in a stratum of calcareous schist. Their outcrop is overlain by gossan, in which particles of native gold appear to have been found. Certain it is that arsenical pyrites, which was at one time met with as an accessory mineral, contained six ounces of gold per ton. As it has been observed above that proofs of the presence of igneous rock accompany a loch, so here also, though few and scattered fragments only have been found.

Glen Fallich.—At the head of Glen Fallich, near Crianlarich, a galena-vein, of about 3 feet in width, and striking from N.N.E. to S.S.W., has been discovered. The vein is in all respects of the same structure as the other veins, to be described presently.

Tyndrum.—The two veins intersecting the mica-schist at Tyndrum, at the head of Glen Dochart, are of importance. The first of these veins runs through a stratum of granular quartz; and the other lies close to the junction of this quartzose mica-schist and the true mica-schist. While the *former* follows a north-north-eastern and

south-south-western direction, the *latter* approaches nearer to a north-east and south-west line. In consequence, both veins should unite into one,—as has actually been observed, though without increase of the ores. Furthermore, while the *first vein* dips in its higher parts towards the north-west, but soon changes to the opposite direction at a very acute angle, and later with the constant angle of 68°, the *second* vein steadily and regularly dips to the south-west at an angle of 75°. In consequence of their respective dips, both veins meet below. Therefore, and on account of their respective bearing and dip, their junction is effected in a gently sloping line ascending from north-east to south-west. Underneath this line the lead-ore evidently is on the decrease; and the mines therefore are only explored in the higher parts.

In reference to the geological age of both veins, the first is the older, and the second the later formation. The first vein above the line of junction is intersected and slightly dislocated by two cross-courses, which terminate distinctly at the most regular westerly wall of the second vein. Underneath the line of junction, both veins, being closely linked together, are traversed and considerably dislocated by the third cross-course. By means of these facts, five geological periods became discernible, viz.:—

a. The formation of the first vein.
b. Its intersection by the first cross-course.
c. Its intersection by the second cross-course.
d. The formation of the second vein; and
e. The intersection of the united veins by the third cross-course.

It is self-evident that such powerful and repeated changes, extending over only about 600 square yards, or about 1-500th of a square mile, lead to the conclusion of powerful agencies having been at work, thereby seriously affecting the surrounding rock-formation. And such evidence, if transferred, by way of analogy, to the many unexplored square miles, offers sufficient material for geological calculations, particularly relative to the formation of valleys of elevation, and the peculiar features of the Highlands in general.

Besides the above-mentioned cross-courses, there exists at Tyndrum a cross lead-ore vein, combining the first vein with the second one, from east to west. The respective widths of these three veins are from 2 to $3\frac{1}{2}$ feet, from 4 to 18 feet, and from $1\frac{1}{2}$ to $2\frac{1}{2}$ feet. The first vein contains solid galena; the second one has fine-grained lead-ore and silicate of lead; the third vein contains both varieties. The first vein is the most mineralized, containing mainly solid quartz, several of the common spars, copper-pyrites, and blende, seldom cobalt-ore, titanic iron-ore, and iron-pyrites. The second vein contains many fragments of soft mica-schist, intermixed with frangible quartz, copper-pyrites, and blende. The third vein participates in the nature of both the others.

The vein first named is characterized by its extent; for it may be traced through valleys and over hills for a distance of more than eight miles.

The mines of Tyndrum have, with intervals, been worked at

different times; and records tell that they have been extensively worked for more than a hundred years. As an evidence thereof, it may be mentioned that a sinking on the main vein had been cut out, measuring 350 feet in length and 72 feet in depth, thus forming an underground lake which was tapped only some months ago, whereby the richer part of the ore-field became accessible.

About half a mile from those veins a powerful quartz-vein, of nearly the same bearings, attracts attention. It stands out like a parapet, running for a great distance over declivities and eminences; and it has produced great changes in the adjacent strata. It may be observed that its influence has towards the east been very suddenly and distinctly stopped at the fissure of the second vein; but it is more difficult to define that influence in the western direction, where the alteration of the rock appears to die gradually away. The stratum at this place consists chiefly of granular quartz, intermixed with much felspar, and with minute scales of mica, together with small specks of iron-pyrites. The strata on the east and west walls of the quartz-vein have been altered from a horizontal position to considerable though variable inclinations with various contortions. Its width is often more than 4 feet, in which case the quartz is quite compact and pure. When the vein is smaller, a tendency towards crystallization begins, and at the same time traces of lead-ore appear. Not only at the very top of the hill, where the quartz-vein intersects the rock, but also at its foot in the valley of Glenlochy, hollows filled with water have been formed, almost as if to verify beyond doubt the theory of elevation and sinking. The former lake is situated at an elevation of about 1500 feet, and the latter, Lochnabuie, at about 800 feet above the sea-level. This quartz-vein, though here and there not outcropping, is traceable for about ten miles.

Southern Slope of Glenlochy.—At the opposite (the southern) slope of the valley of Glenlochy many more such quartz-veins, of similar structure and producing similar appearances, intersect the east-and-westerly course of the mountain-ridge. Among them, one is distinguished by being loaded with more minerals than the rest; so that it forms almost a middle member between the two perfect lead-ore veins and the barren quartz-veins.

Igneous Rocks at Tyndrum.—In the neighbourhood of the district under consideration only a few traces of intersecting rocks have been found. These traces relate to syenite and greenstone. Close to the bridge of the village near Tyndrum a trap-vein intersects the mica-schist; its width is 40 feet. It may be mentioned that iron-pyrites is of the most frequent occurrence in all parts of the district.

Conclusion.—The foregoing remarks on this mountainous country afford proofs that a great variety of minerals, mostly as regular formations, may be found,—and that, too, in nearly all parts which have been or could be examined. By far the most discoveries have been made by the Marquess of Breadalbane, who, by his attachment to geological researches and to the exploration of useful minerals, became the discoverer of the silver- and copper-mines at Loch Tay.

It is remarkable that the Highlands of Scotland, taken as a whole, have afforded so few opportunities for mining operations. Is it that the rocks, having been so often disturbed, have not allowed the quiet settling down of larger mineral deposits? or have the mineral deposits been broken up and scattered about by those more or less evident eruptions? If such be the main causes, then a fair comparison may be drawn between these highlands and others on the Continent,—namely, Switzerland, where, as here, a great variety of minerals is found, but seldom in such abundance as to invite mining-undertakings.

Finally, in this communication I have studiously avoided any reference to the details published about eighteen years ago by the Highland Society. What I have here stated confirms in their essential parts former observations. The additional facts brought to light since that time, and some alterations in the conclusions arrived at, help us partly to generalize, and partly to illustrate in detail the views formerly published.

March 28, 1860.

The Duke of Marlborough, and W. P. Jervis, Esq., Northwick Terrace, Maida Hill, were elected Fellows.

The following communications were read:—

1. *Notes about* Spitzbergen *in* 1859. By James Lamont, Esq., F.G.S.

[With Appendix.]

Having passed upwards of two months last summer (1859) on the coast of Spitzbergen, and amongst the great fields of floating ice in the surrounding seas, I beg to offer the few following observations.

I left Leith on the 6th of June; reached Hammerfest on the 23rd, left Hammerfest on the 26th, and arrived at Spitzbergen on the 2nd of July.

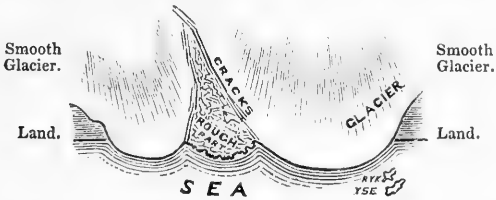
We found a large quantity of heavy drift-ice off the south-eastern end of Spitzbergen and amongst the "Thousand Islands." At the mouth of Stour Fiord ("Wybe Jan's Water" of the charts) we met two small sealing-vessels, the masters of which told us that the north coast was unapproachable this summer, on account of the ice being jammed against the north-western corner of the island, about Hakluyt's Headland; and we therefore proceeded to coast around the edges of the ice towards the east side of the country.

On the 8th, during a dense fog, we passed the last of the Thousand Islands, and lay-to off the S.E. corner of Edge's Land. The coast from here to Ryke Yse Islands is frightfully barren and desolate, and the mountains are quite destitute of vegetation; these mountains are limestone, and descend abruptly into the sea without the

intervening flat muddy plain so usual in other parts of Spitzbergen*. There are three glaciers on this part of the coast, all protruding into the sea. The two southernmost ones are of no great size; but the third is one of the largest and most remarkable glaciers in Spitzbergen, or, I should think, in any part of the world. It has a frontage towards the sea of upwards of thirty English miles, and protrudes into it in three great semicircular divisions; its protrusion beyond the coast-line seems to be about three or four miles. At the inland side it seems to blend into the sky, and is (like nearly all the Spitzbergen glaciers) connected with one vast interior glacier, which I imagine to occupy about nine-tenths of the surface of the country.

The middle division of this great glacier (of which I annex a rough sketch) seems to have undergone, and to be still undergoing,

Fig. 1.—*Seaward edge of the Great Glacier (about thirty miles wide) on the South-Eastern Coast of Spitzbergen.*



some great disturbance,—probably from rocks or some inequalities underneath it, as for seven or eight miles of its frontage it is indescribably rough and jagged, so that at a little distance, and especially when it is seen dimly through the fog, it resembles more than anything a forest of pine-trees covered with snow. It has, of course, no visible terminal "moraine;" but an extensive submarine bank, extending for about fifteen miles to seaward and along the whole length of its face, may possibly have some connexion with the glacier: the soundings on it seem to average about fifteen fathoms, with a muddy bottom. This bank seems to afford good feeding for the Walruses, as it is well known amongst the hunters as one of the best places for these animals around Spitzbergen; we saw immense numbers (on one occasion a herd of about 400) on the floating ice over this bank.

We lived for about a month within sight of this huge glacier, and had ample opportunities of observing it in all weathers, as we frequently rowed close along its face in the boats. Its seaward face presents an inaccessible precipice of ice along its entire length. These ice-cliffs vary from 20 to 100 feet high; and it is very dangerous to row too near them, as pieces, from the size of a church downwards, are continually being precipitated into the sea: many of the larger fragments ground in this shallow sea.

The rough central division of this glacier continually (and more especially in bright sunny days) emitted a series of loud roaring

* Quart. Journ. Geol. Soc. vol. xvi. p. 151.

explosions, exactly resembling loud and prolonged thunder. These tremendous sounds appeared to be caused by the smooth parts of the glacier falling in at the edges towards the disrupted part, as numerous vast cracks and fissures existed all along the edges of the smooth parts towards where they joined the rough parts. The ice which became detached from the rough part of this glacier appeared to have undergone enormous twisting and squeezing, and I could not previously have believed ice to be a substance of sufficient viscosity to sustain such rough pressure without being crushed into powder.

Much of the ice which floated away from the cliffs of all these glaciers was heavily charged with clay and stones, imbedded into it; and the sea for miles around is sometimes discoloured from the quantity of mud which is washed off this floating *land-ice* by the waves.

This part of the coast is more subject to fog than the west side. This is probably generated by the cold caused by the proximity of this glacier and the quantities of floating ice detached from it.

A very powerful current from the N.E. runs down this coast. It seems never less than three miles an hour; and I have found it as much as six or seven, judging from the impossibility of making head against it in a six-oared boat. As of course ice and boat alike go with the current, one is apt not to discover it until you approach the land or a grounded iceberg. Towards the end of August this north-easterly current became perceptibly very much stronger.

About the end of July we ran southwards into Deeva Bay to obtain shelter from a gale of N.E. wind; we anchored behind Black Point, a promontory which divides Deeva Bay from the sea to the eastwards. This promontory is formed by a flat-topped mountain of about 1200 feet in height; it consists of mud-coloured limestone* and sandstone*, with veins of black stuff resembling coal*. These rocks are stratified with singular horizontality, and the layers or strata are very minute and numerous; only in two or three places have I observed slight bends or deflections from the horizontal in the stratification.

The sides of this mountain form slopes of about 45°, without a particle of vegetation, and are closely and deeply furrowed by water-courses from top to bottom. Enormous quantities of mud and shaly rubbish appear to be carried down these furrowed water-courses; but the base of the mountain is so exposed to the E. and N.E. that no accumulation can take place at the foot of it; on the contrary, it seems to be undergoing very rapid disintegration, as well from the lashing of the winter storms and currents at its foot as from the action of frost and avalanches above.

All the lower hills of South-east Spitzbergen seem to be of the same formation and same configuration as the above, with the exception that inside the gulfs and fiords, where there is shelter from storms and currents, there is generally a flat or gently sloping plain between the hills and the sea, obviously formed by the washings and débris of the hills. It is very curious and instructive to observe how

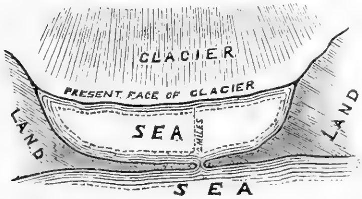
* Specimens sent. (See Appendix, p. 436.)

the mountains appear to melt and crumble away like mole-hills under the gigantic force and pressure of frost and glacier; and I can imagine nothing better calculated to give one an idea of the appearance Scotland must have presented during the glacial epoch than a visit to Spitzbergen. I have observed many appearances in the glens of the Highlands, and particularly in Glen Turrit in Perthshire, which were enigmas to me at the time, but which are very plain reading after observing the action of ice and glaciers in Spitzbergen.

Deeva Bay is marked in the charts as being unexplored at the top; but we hunted all over it in the boats. It is very shallow and very muddy, and had five or six square miles of "fast ice" of one winter's growth at the extreme end. We killed three Bears and a good many Seals about this sheet of ice.

There are several extensive glaciers on both sides of the Bay. One of these glaciers has a curious detached "moraine," something like a breakwater, in front of it: I annex a sketch showing its posi-

Fig. 2.—*Glacier in Deeva Bay.*



tion and shape. This "moraine" is formed entirely of mud or earth, more or less consolidated; it extends three or four miles in length, by 200 to 400 yards in breadth, and is 20 or 30 feet in height. The glacier does not appear to have been in contact with it for many years, as the earth appeared to have been long undisturbed, and many Mosses and Saxifrages were beginning to grow upon it. The glacier and this "moraine" are distant at least two miles, and were divided by a sheet of water mostly covered by "fast" ice. The glacier blended so insensibly into this "fast" ice, that at first I thought the latter actually formed part of the glacier, until with my glass I discovered some loose pieces moving about, and several Seals lying upon it and diving into the interstices. I could not form any idea quite satisfactory to my own mind as to how this "moraine" had come to be separated so far from the glacier which had obviously occasioned its existence by great immediate pressure. I picked up some shells * on the "moraine."

The lower hills of South-east Spitzbergen very much resemble the long dreary ranges of limestone hills which hem-in on both sides the valley of the Nile from Cairo to Assouan; and this resemblance exists both in their colour, size, shape, inclination, and general appearance, as well as in their almost total solitude and the absence

* Labelled specimens sent. (See Appendix, p. 437.)

of life and vegetation. The higher range of mountains (always perfectly inaccessible) in the interior of both the main islands is apparently of granite—and, judging by the occasional pieces which somehow or other find their way to the shore and islands, of red granite.

After killing or frightening all the bears and seals to be found in Deeva Bay, we dropped down to the Thousand Islands, and on the first one we approached we discovered and killed a Bear occupied in gathering and swallowing the eggs of thousands of Eider-ducks and other birds which had their nests on the land. On this island I first observed the phenomenon called "red snow," of which a description is familiar to all readers of Arctic voyages. I may remark that it seemed to me that in this case it was attributable to nothing but the droppings of the millions of Little Auks (*Alca Alle*), which feed almost entirely on shrimps, and consequently void a reddish substance.

These islands are most absurdly named "the Thousand," as there are not in reality 100 of them: they are also put down in the charts as if they were thickly and regularly clustered together; whereas they are often out of sight of one another, and twenty or thirty miles apart. I nowhere observed more than five or six in a cluster, even by including rocks or skerries of small size. Hope Island is also most erroneously marked in all the charts as lying far to the south of the Thousand Islands; it is in reality about *forty-five miles due east* from Black Point: this error is notorious to all the Norwegian seal-hunters who frequent the coast, and I quite satisfied myself of it by observation.

The Thousand Islands are all composed of coarse-grained greenstone, in some places assuming the form of indistinct hexagonal columns. These columns appear very much shaken, as if ready to fall to pieces. The top of the columns and all the corners are much rounded and worn, as if they were half-formed into boulders already. This I suppose is the case, as millions of boulders, very smooth and rounded, and formed of the same rock, lie strewn on all the islands. The average size of the boulders is a cubic foot or so, and I saw none bigger than about 3 feet in diameter. They are curiously packed in some places, as if laid level, for walking on, by the hand of man; I presume this appearance has been caused by the pressure and grinding of icebergs when the islands lay under the sea. I was a little surprised to find on some of these islands, amongst the native boulders, a few very round boulders of red granite*, from a cubic foot downwards in size. I am certain there is no granite *in situ* nearer than the tops of the Spitzbergen Mountains, distant from forty to sixty miles and bearing W. to N.N.E. There are also occasional small water-worn boulders of limestone†, and of a hard reddish stone like porphyry ‡.

There are great quantities of drift-wood (evidently Pine of some sort) on all these islands, as well as on the south coasts of the Spitz-

* Small specimens sent. (See Appendix, p. 436.)
† Specimens. ‡ Specimens. (See Appendix, p. 436.)

bergen mainland: some of it is much worm-eaten*. The sealers say it is floated from the rivers of Siberia, which I believe to be the case, as there is little or no Pine-wood on the opposite coast of Norwegian Lapland. I have seen some few very large trees with the roots on; but the wood is mostly small and a good deal broken up, also very much bleached and water-worn. Much of it lies at least 30 feet above high-water mark. I nowhere observed any wood *in situ.*

On all parts of Spitzbergen and its islands which I have visited, I have found numerous bones of Whales far inland and high above the sea-level; I send several specimens labelled. Some of these were discovered and brought to me by the sailing-master of my yacht, so that I cannot personally vouch for the accuracy of the heights and distances marked on all of them; but one large piece of a jawbone (sent in October 1859) was discovered by myself at 40 feet above the sea. It was part of an entire skeleton, which lay half-buried in moss at about half-a-mile distance from the sea in Walter Thymen's Straits, North-east Spitzbergen. There was also a terrace of trap-rocks higher than the moss, intervening between the latter and the sea.

In one of the Thousand Islands I counted eleven very large jawbones, along with many bones forming other parts of the Whale's skeleton, all lying close together in a slight depression about 10 feet above the sea-level.

On this same island I observed what I take to be a further proof of the recent upheaval of the land; this was a sort of furrow or trench about 100 yards long, by 3 to 4 feet deep, and 3 or 4 feet broad, ploughed up amongst the boulders: I presume this was caused by an iceberg grazing along the surface while yet the island lay under water. It was on a gentle slope about 20 feet above the sea, and extended from N.E. to S.W.,—exactly the run of the current-borne ice at the present day.

These islands are a favourite haunt of the Walrus; particularly towards the autumn, when they assemble in vast herds, and lie *heaped up* on dry land *without moving or feeding* for weeks at a time. On these occasions, if they are discovered by the hunters, immense numbers are sometimes slaughtered, as their numbers impede their escape; and they are also said to be sometimes so lethargic as to allow themselves to be killed almost without resistance. In 1858 I visited an island on which six years previously 900 walruses had been slain in a few hours by sixteen men with lances. There were said to be 3000 or 4000 walruses on the island at the time. The men had not been able to remove the skins and blubber of more than 300; and the 900 carcases still remain putrefying on the island. The smell is horrible even at two miles' distance, the carcases lying two and even three deep in places.

I frequently opened the stomachs of both Walruses and Seals, and found the food of the Walrus to consist principally of shells, sandworms, and shrimps; that of the Seals, of shrimps and small fish.

* Specimens.

Nothing connected with the geology of Spitzbergen is more striking than the *absence of pebble-beaches.* Nowhere along the whole S., S.E., or S.W. coasts, nor amongst the Thousand Islands, nor up the great sound called "Stour Fiord," did I anywhere observe what can be called a pebble-beach. The coast everywhere consists of either mud, or cliffs of ice, or rocks. In some places, indeed, principally amongst the Thousand Islands, I have found small quantities of what might be called gravel; but it is very coarse, the fragments being seldom less than a cubic inch* in size, and invariably almost wholly composed of the same coarse trap-rock which forms the islands. It is generally mixed with very coarse blackish sand, evidently formed by the disintegration of the same rocks. I send several bags of gravel labelled*, obtained both from different points of the coast-line, and from different elevations inland. Numbers of shells abound, both on the shore and far inland. I send a bag of specimens†.

Towards the end of August, the weather got very wild amongst the Thousand Islands,—there being perpetual gales of N.E. wind with snow, and a tremendous current from the same direction bringing down quantities of heavy ice. We then sailed up Stour Fiord to shoot Reindeer, about twenty or twenty-five miles to the north of Thymen's Straits. This Sound makes a turn abruptly due E., instead of continuing N. as marked in the charts. I followed the shore in a boat about fifteen miles from this angle, going E. all the way, until at last the Sound abruptly narrowed to a sort of gut about two miles broad. Such a very strong stream ran down this gut that we found it impossible to row up it, and the shore was impracticable for walking; so that I was reluctantly obliged to give up its exploration. None of my Norwegian crew had ever been so far up before; and no one seems to know whether this gut communicates with the sea to the east or not.

I am, however, very strongly of opinion myself that *it does,* and that we were then within a very few miles of the East Sea—probably at Henloopen Straits. I found this opinion on the fact of such a very strong current setting down the gut, and also because, although the day was unusually bright and clear, we could see no land in that direction higher than the rocks we stood on—20 or 30 feet. These rocks were all low, flattish, and very rugged hills of coarse reddish trap (or porphyry?), and were very much smoothed on the tops, as if by quantities of ice having travelled over them in by-gone times. Numerous small glaciers lay here and there amongst them; and the whole country to the E. and N.E. looked gloomy, sterile, and desolate to the last degree.

There are some beautiful mossy flats and valleys on the east side of Stour Fiord, abounding with Reindeer. From their excessive tameness, some of these deer appeared never to have seen a human being, nor *anything that could hurt them,* in their lives.

In the upper part of this Sound, I observed two very remarkable mountains: one was a long hill of about 1500 feet high, and seem-

* Specimens. † Specimens. (See Appendix, p. 438.)

ingly composed of the same grey, shaly, sandy limestone as almost all the lower hills of East Spitzbergen; but it had a perfectly flat top, and the upper stratum, as well as another band about half-way up, seemed to consist of coal or some other black substance. This mountain was a long way off; but I think these black bands were each 20 or 30 feet thick; and they seemed to be of harder substance than the rest of the mountain, as the edges of both of them stood up perpendicularly instead of participating in the 45° slope of the mountain. At one side, where the mountain turned inland, I could perceive that the lower of these two black bands thinned away gradually to nothing.

Of the other hill, I can hardly hope to give a description which will convey an idea of its singularly grand and picturesque appearance. It was a small hill, apparently not more than three or four miles in circumference at the base, and about 600 or 700 feet high. The lower two-thirds of its height consisted of a steep talus of débris, thickly covered with a carpeting of brilliant mosses of every imaginable tint. The upper third of the hill was composed of bright-red or russet-coloured rocks, arranged in rough perpendicular columns, looking exactly like a number of enormous half-decayed trunks of trees standing on end in a huge faggot or bundle. The detritus of this hill seemed to afford very rich pasture for the Reindeer: I shot nine around the foot of it.

The last parts of Spitzbergen which I visited were Bell Sound and Ice Fiord, on the west coast. These are both fine, large, well-sheltered harbours, surrounded by high mountains, and are the first and the last bays which are clear of drift-ice. We remained in Ice Fiord until the 4th September, when the weather was still very much milder than we had found it on the E. and S. coasts in July and August.

The hills around these bays are limestone, but not nearly so compact and plainly stratified as in Eastern Spitzbergen. They are extraordinarily full of fossils; in some places it appears as if the hills were actually composed of fossils*. Quantities of recent shells† also lie about the watercourses and muddy flats. The rocks here appear to be crumbling away very fast. In Bell Sound I obtained a piece of siliceous limestone† which was sticking out of the face of a limestone cliff like a sign-post, about 2 feet long.

In Ice Fiord I observed three well-defined ancient beaches, rising one above the other, at intervals of about 20 feet.

In the bed of a torrent in the same bay I found some round stones exactly resembling rusty cannon-shot of different sizes‡.

I met a small vessel which in July touched at the land to the N.E. of Spitzbergen, marked in the charts as Gillies Land; but I could obtain no information from them respecting it, except that "it was very like Spitzbergen, and contained no Walruses nor Reindeer."

* See Mr. Salter's Appendix. † Many specimens sent.

‡ Sent. (See Appendix, p. 436.)

APPENDIX.

Specimens sent by Mr. Lamont, *only generally noticed by him in the above communication.*

Black Point.—Greyish, fine-grained, laminated sandstone, sometimes micaceous.

——. Brownish, fine-grained, micaceous, shaly sandstone, weathering white.

——. Pebbles of hard coal.

——. Brownish-grey limestone, with *Nucula, Aviculopecten,* and *Spirifer.*

——. Grey limestone with calcareous veins. With a trace of a Calamite?

——. Fossil wood, with attached coaly matter.

Thousand Islands.—More or less rounded fragments of—

Compact red syenitic rock.
Grey compact siliceous limestone with Corals, *Aviculopecten, Streptorhynchus,* &c.
Brownish argillaceous rock.
Yellowish fossiliferous siliceous limestone.
White fossiliferous limestone.
Black flint with chalcedonic vein.
White flint or chert.
Purplish semitransparent quartz-rock.
Greenstone.
Thin-bedded, grey, compact, siliceo-argillaceous rock, with a large *Aviculopecten.*
Hard compact sandstone.
Red, highly siliceous limestone.
Greenstone, coarse-grained, with weathered face.

Ryke Yse Islands.—Rounded fragments of grey compact limestone with *Fenestellæ* and Corals.

Ice Sound.—Fine-grained, compact, dark-grey sandstone, weathering ferruginous.

——. Ferruginous nodules (exfoliating) of the size of cannon-balls.

Island, Bell Sound.—Weathered fragment of argillo-siliceous dark-grey rock, with *Fenestella* and Corals.

——. Hard reddish ferruginous rock with pebbles of Lydian stone.

——. Fossils, from 200 feet above the sea, and 350 yards inland. (See Mr. Salter's Appendix.)

——. Brownish-grey, micaceous, compact, fine-grained sandstone pebbles, with trace of the cast of an *Aviculopecten*?

Bell Sound.—Fossils, from 400 feet above the sea-level. (See Mr. Salter's Appendix.)

Moraine in Deeva Bay.—Brown claystone, weathering reddish-purple.

Without Localities.—

Ferruginous nodule, small.

Hard ferruginous sandstone with small ferruginous nodule.

Siliceous conglomerate.

Boulder of conglomerate, or coarse pebbly grit; pebbles of white and dark-grey quartz and Lydian stone, cement calcareous.

White quartz-rock.

Stem-like piece of brownish fine-grained sandstone (? cast of a ripple-mark).

Light-grey friable sandstone.

Dark-grey mudstone (calcareo-argillaceous) with impression of shell.

Water-worn fragment of tortuously laminated calcareous slate.

Pebble of grey argillaceous limestone with calc-spar vein.

Bouldered piece of grey siliceous limestone with *Productus* and Corals.

Grey siliceous limestone with *Orthis* and *Productus*, with weathered surface.

White crystalline limestone with *Spirifer cristatus* and Corals, having a weathered surface.

White siliceous limestone with Corals, *Encrinites*, and Shells.

Black siliceous limestone with calcareous veins.

Weathered fragment of white Encrinital chert with Corals, *Bryozoa*?, and *Productus*.

Black flint with whitish mottlings, splinters.

Red siliceous limestone with a rounded, weathered surface. Probably from the Thousand Islands.

(Islands to the South-east?) Weathered fragment of white limestone with *Productus*, *Spirifer alatus*, and a large foliaceous Coral (*Stenopora*).

Recent Shells (determined by S. P. Woodward, Esq., F.G.S.).

1. From the Thousand Isles.
Buccinum undatum, var. (*cyaneum*??).

2. From Bell Sound, at about high-water mark.
Fusus despectus, L., var. (= *F. borealis*, Philippi).
Buccinum glaciale, L. (=*B. angulosum*=*B. polare*, Beck).
Margarita undulata (=*Grœnlandica*) inside a *Buccinum*.
Buccinum scalariforme?
Balanus crenatus, var. *Scoticus*, probably.
Fusus Kroeyeri, Möller.
Cardium Islandicum (=*ciliatum*).
Cardium Grœnlandicum (broken).
—— —— (very fine).
Saxicava arctica.
Mya Uddevallensis (*truncata*, var.).
Astarte borealis, Chemn., var. (=*semisulcata*, Leach; =*lactea*, Broderip).

Mya truncata, var. *Uddevallensis*.
Pecten Islandicus.
Nullipore, with *Saxicava*.

3. From Bell Sound, at about $1\frac{1}{2}$ to 2 miles inland and 400 or 500 feet above the sea-level.
Buccinum glaciale ($1\frac{1}{2}$ to 2 miles inland, 400 and 500 feet high).

4. From the Moraine of a glacier in Deeva Bay.
Astarte borealis (var. *semisulcata*).
—— *compressa*, Mont., var. *striata*.
Mya truncata, var. *Uddevallensis*.

SPECIMENS *of* BONES *obtained by* MR. LAMONT *in* SPITZBERGEN.

1. Fragment of vertebra of Whale, rotten. Bell Sound. Half a mile from the sea. 100 feet above the sea.
2. Fragment of bone. Half a mile from the sea at Bell Sound. 100 feet above the sea.
3. Cranium of a small *Delphinopterus leucas* (White Whale or Beluga). Bell Sound. 300 yards from the sea. 80 feet above the sea.
4. Anterior rib of a Whale. Bell Sound. 500 yards from the sea. 80 feet high.
5. Small lumbar vertebra of Beluga (?) Bell Sound. Nearly buried at 70 feet above high-tide mark.
6. Fragment of bone of Whale. Bell Sound. Buried in bank 50 feet above the sea.
7. Half of a caudal vertebra of Whale. *Balæna mysticetus* (?) Bell Sound. A little above high-water mark.
8. Caudal vertebra of Whale. Found among the boulders at high-water mark. Coloured ferruginous.
9. Small cervical vertebra of Beluga?
10. Tibia and fibula of hind left leg of a Walrus.
11. Large caudal vertebra of Whale.
12. Part of lower jaw of Whale. Walter Thymen's Straits. Half a mile from the sea, and 40 feet above sea-level.

Description of the GRAVELS *from* SPITZBERGEN *collected by* MR. LAMONT. By J. PRESTWICH, Esq., F.G.S.

1. Gravel from Bell Sound, 60 feet above high-water mark. Grey gravel of small subangular fragments of dark-grey argillaceous and quartzose slaty rocks, some portions calcareous, and a few fragments of grey sandstone, mixed with a small proportion of earth. None of the fragments are above two ounces in weight, the bulk being of small size (seventy to the ounce). Amongst these subangular fragments there are, however, a few small round pebbles of a dark-grey limestone, and a few perfectly angular fragments of slate.

There are no shells, nor any characters on any of the fragments in the gravel to indicate a beach-origin. The mass, in fact, looks much

more like the smaller fragments of a moraine. None of the fragments, however, are scratched or striated.

2. Gravel from Bell Sound, 20 feet above high-water. Dark-coloured grit, clean and uniform in texture, consisting of small subangular fragments of a black hornblende-slate (like that of No. 4) about the size of cress-seed, with a very few flattish pebbles of the size of peas, and still fewer rounded pebbles of the size of marbles. There are no fragments of shells.

3. Gravel from an island in Bell Sound, a little above high-water. Small greyish-green gravel of flat angular fragments of greenish mica-slate, with a few pieces of quartz. None of the fragments are an ounce in weight. The bulk consists of pieces of about thirty to the ounce. No matrix of any sort. No fragments of shells. This gravel has the appearance of rock-débris *in situ*.

4. Gravel from Bell Sound, half-way between high- and low-water. Ordinary clean and well-worn small beach-shingle, the smaller fragments being more or less subangular, and the larger ones more or less rounded: no fragments above three-quarters of an ounce in weight; and the bulk 117 to the ounce. It is composed mostly of compact black hornblende-slate (like that of No. 2), compact grey sandstone, and some grey limestone and a very little quartz. There are no shells, nor scratched pebbles. It is much like the shingle of parts of our own coast.

5. Gravel from Bell Sound, low-water anchorage. Subangular small fragments of micaceous slates, with a few flat angular fragments of limestone. Not one well-rounded pebble; few even of the fragments are much worn. There are no shells. This looks much like the small débris in an old slate-quarry.

Note on the Fossils *from* Spitzbergen.

By J. W. Salter, Esq., F.G.S.

The specimens of fossils brought by Mr. Lamont are chiefly from three localities, viz.:—

1. Bell Sound (at 400 feet above the sea-level), western side of the island;

2. Island in Bell Sound (at 200 feet above the sea, and 350 yards from the shore); and

3. Black Point, near the S.E. angle of Spitzbergen, close to which are the Thousand Isles.

From Bell Sound only a few species were collected; and these are the same as those from the small island in the same Sound. One is a large *Productus*, which I cannot identify completely with any British species. It may be a large variety of one of our common shells, *P. semireticulatus*, or even a form of *P. costatus*. In any case it is of a Carboniferous type.

The specimens from the island in Bell Sound are much more numerous; and in a grey limestone we have—

1. *Athyris* or *Spirifer*, a large smooth species, nearly 3 inches

across, without any definite hinge-line, and with very strong ventral muscular impressions. The shell is much depressed.

2. *Productus costatus*, Sowerby, very large, and deeply bilobed.—Abundant.

3. *Productus*, the large striate species above mentioned.

4. *P. Humboldtii*, D'Orbigny, two or three specimens.

5. *P. mammatus*, Keyserling ?, or an allied species, without large scattered spines. This species occurs in Arctic America, having been brought by Capt. Belcher from the point opposite Exmouth Island. It is the *P. Leplayii* of De Koninck's paper on the Fossils from Spitzbergen, but not, I think, of De Verneuil, who described that species in 'Russia in Europe.'

Von Buch quotes the *Productus giganteus* from the South Cape and from Bell Sound; this is not noticed at all in Prof. Koninck's list (1849, *op. cit.* p. 633).

6. *Camarophoria*, a large species, not unlike in shape to the *Rhynchonella acuminata* of the Carboniferous limestone, but ribbed throughout.

7. *Spirifer Keilhavii*, Von Buch. Several specimens. This, more than any other shell, tends to connect the Spitzbergen formation with surrounding districts. *Sp. Keilhavii* was described in the Berlin Trans. for May 1846. The specimens were brought home by Keilhau, from the rocks of Bear Island in 74° 30′ N. lat., half-way between Norway and Spitzbergen. In the same paper Von Buch notices that the locality of Bell Sound had been visited by French naturalists (M. Robert and the Scientific Commission which explored these seas in 1839), and that the same *Producti* and *Spirifer* (*S. Keilhavii*) were found there which occurred at Bear Island. And, inasmuch as the *Producti* are the common British species *P. giganteus* and *P. Cora*, there can be no doubt whatever of the formation to which *Spirifer Keilhavii* belongs. Count Keyserling described a variety of it from Petschora Land, under another name; and in the Appendix to Belcher's 'Last of the Arctic Voyages' I have figured and described this shell from the Carboniferous rocks of North Albert Land—Captain Belcher's furthest point. Numerous *Producti* occurred with it, two of which, if not more, are identical with the Spitzbergen species. I notice this more particularly, because in two communications to the Royal Academy of Brussels (Bulletin, vols. xiii. and xvi.) Prof. de Koninck has described the Bell Sound fossils as Permian, and not Carboniferous species, and has given figures of several of them. In a short résumé of the Arctic Geology read by myself to the British Association, 1855, I have used this fact as illustrative of the regularity of the Great Arctic basin of palæozoic rocks (Trans. Sect. p. 211).

One species only which appears to me of Permian date occurs in a loose block (without definite locality) and will be presently noticed. It would be somewhat remarkable if all the specimens brought home by M. Robert should prove to be Permian, while those from the same locality before us are mostly of Carboniferous type. The larger and more conspicuous shells do not seem to have been met with by M. Robert in his voyage.

8. *Fenestella,* two species, one with very large meshes.
9. Sponges (?); large, stem-like and cake-like in shape.

Specimens without definite localities:—

10. *Spirifer cristatus,* Schloth. *S. octoplicatus* of the Mountain-limestone is now regarded as the same species.
11. *Streptorhynchus crenistria,* or an allied form.
12. *Zaphrentis Ovibos,* Salter (?). Probably an Arctic species.
13. *Stenopora*; a large branched species, like *S. Tasmaniensis* of Lonsdale. This occurs at Bell Sound also.
14. *Syringopora,* large fragments.
15. A new genus, in all probability of the *Fenestellidæ,* consisting of thick stems branching regularly from opposite sides, the smaller branches also opposite, and coalescing with their neighbours so as to form a quadrangular network. But for this coalescence, it might be a gigantic *Thamniscus* or *Ichthyorhachis.* As the poriferous face is not seen, it is better not to give a new generic name.

From Black Point, in shaly beds, which seem to be associated with the coal, slabs were obtained with numerous shells and some fragments of plants.

16. *Nucula,* abundant; and amongst these is a small
17. *Aviculopecten,* and a *Spirifer* with broad ribs.
18. *Aviculopecten.* A large species (looking like the *A. papyraceus* of our own coal-shales magnified), found in the gravel among the Thousand Isles; it probably came from these beds.

A weathered block of white limestone, probably from the islands on the south-eastern side of Spitzbergen*, contains the only truly Permian species which I have seen among these specimens, viz.,—

19. *Spirifer alatus,* Schloth., a common fossil of the Zechstein.
20. *Productus,* a small species. (*P. horridus* of De Koninck's list, but apparently too deeply lobed.)
21. *Stenopora,* a large foliaceous flattened species.

Spirifer octoplicatus (*cristatus*), above mentioned, also occurs in similar whitish limestone. These may possibly have all come from the locality whence M. Robert's original specimens were found; but it would appear that they are not by any means the prevailing fossils of the island.

The general aspect of the fossils collected by Mr. Lamont is unquestionably Carboniferous; and some of the species have a wide diffusion. *Productus costatus* ranges from India to the Mississippi, and *P. semireticulatus* (which I think is only a variety of the same species) has even a wider range†. *P. Humboldtii* is found in Russia

* With regard to this specimen, the author, in reply to an inquiry on the subject, states—"The loose block of white limestone to which you refer as 'having a Permian aspect' was, if I mistake not, picked up on one of the islands to the S.E. of Edge's Land. It is unlike any rock I saw *in situ*; and, as it is evidently a travelled block, I think it not improbable that it does not belong to Spitzbergen at all, but may have been transported by the drift-ice from Commander Gillies's Land or some other unknown country to the north-east."—April 21, 1860.

† To Australia (M'Coy).

and South America. Our *P. mammatus*? is probably distinct from the Russian species, but it is at all events the same as one in Captain Belcher's collection*.

The size of the fossils, both of the Shells and Bryozoa, is remarkable, and, taken in conjunction with the presence of large land-plants in the coal, would seem to indicate a great decrease of temperature in the Arctic region since the Carboniferous period. The shells are larger, too, than the corresponding species in our own mountain-limestone.

Notes on the ROCK-SPECIMENS *from* SPITZBERGEN, *collected by* Capt. PARRY *and* Lieut. FOSTER. By L. HORNER, Esq., PRES. G.S., &c.

Captain Edward Parry, in his voyage to the North Pole, visited the coasts of Spitzbergen in the summer of 1827; and in January 1828 this Society received from him, and from Lieutenant Foster who accompanied him, a collection of specimens of rocks, which they had collected there; but no description of the specimens exists, either in the 'Transactions' or in the 'Proceedings' of the Society, nor can any manuscript description of them be found among the archives of the Society. It has therefore been thought advisable to take advantage of the opportunity afforded by Mr. Lamont's communication, to give an account of the specimens in the possession of the Society presented by the above-named officers, prefacing those descriptions by a few extracts from the geological observations contained in Captain Parry's 'Narrative†.'

The 'Hecla,' surveying ship, first reached the north-western coast of Spitzbergen, and then, stretching eastward, along the low point of Verlegen Hoek, they made sail to the N.N.E. towards the Seven Islands, passing Low Island. They found the whole of the coast, from Low Island to Black Point, and apparently as far as Walden Island, inaccessible by reason of one continuous and heavy ice-floe, everywhere attached to the shores. Sounding in lat. 80° 16′ 40″, five leagues north of Verlegen Hoek, they found the bottom at 90 fathoms.

On the 14th of June they reached lat. 81° 5′ 32″, long. 19° 34′ E., Little Table Island bearing S. six or seven leagues; and here they found the depth of water 97 fathoms, with a bottom of greenish mud. Little Table Island is described as a craggy rock, rising from 400 to 500 feet above the sea-level, having a low islet at its northern end,—both together occupying an extent of about a third of a square mile. They landed on the islet, naming it after Lieutenant Ross of the 'Hecla' (the present Sir James Ross), and found it to rise about 100 feet above the sea-level, and to consist of gneiss, having imbedded garnets in some parts.

Specimen from Ross Islet.

1. Grey foliated orthoclase-granite, with a gneissic tendency.

* It is closely and finely striate, and has spines along the hinge-line only.
† Narrative of an Attempt to reach the North Pole in the year 1827.

They next landed on Walden Island, on the south-eastern or lowest part, and found it composed of coarse-grained red and grey granite with much mica. They ascended to a height of from 200 to 300 feet, and found the same granite. On the face of the rock they observed veins of a finer grey granite, from 12 to 20 inches wide, bordered by a ribbon of whitish felspar, about 3 inches wide on each side. Large rounded masses of granite in regular horizontal beds were lying at the height of 30 or 40 feet above the present sea-level, giving the idea of their having once been washed by it. At a distance of four miles from the shore, they found bottom at 25 fathoms.

Specimens from Walden Island.

2, 3. Grey orthoclase-granite, similar to that of Ross Islet.
4. Granite; the orthoclase-felspar of a pale red colour, with much silvery mica.
5. Orthoclase-porphyry.
6. Compact greenstone, or diorite.
8. Scoriaceous lava.

They landed on Low Island, and found the low beach principally composed of rounded fragments of limestone intermixed with some of clay-slate, and several rounded fragments of pumice*; the beach was also lined with drift-wood. The west point of the island is composed of a schistose quartz-rock dipping 70° S.E. with a fine smooth beach of small pebbles of quartz and clay-slate. Beds of clay-slate occur further inland, on the S.W. shore, of a blue, red, and yellow colour, dipping in various directions.

Specimens from Low Island.

9, 10. White granular quartz-rock, with a bedded structure, probably a compact sandstone, without mica.
11. Granular quartz, similar to 9 and 10, but of a red colour.
12. Schistose grey limestone, with paillettes of mica.
13. Compact white dolomitic (?) limestone.
14. Compact grey limestone.
15. A purple calcareo-argillaceous sandstone.
16. A red argillaceous sandstone, highly calcareous.

Landing on the shore opposite to the south coast of Low Island, they found the rocks to be different from any they had yet met with; they consisted chiefly of a black marble with white and red veins intersecting it. In some places there were beds of clay-slate, of considerable extent. They found one piece of bituminous wood-coal, which burned with a bright flame and emitted a pleasant odour. A great number of small rounded pieces of pumice were also found on this part of the coast. They named the spot Marble Point.

Specimens from Marble Point.

37. Grey compact limestone, with veins of calcite.

* Probably floated from the volcanic Island of Jan Mayen to the S.W.—L. H.

38. Crystalline calcite, a portion of a vein.
39. Thinly laminated calcareo-argillaceous sandstone.

In Mussell Bay, ten miles south of Verlegen Hoek, they found mica-slate with an eastern dip generally 70°, but sometimes more. At Red Beach, further west, they found a clay-slate of a brownish-red colour.

Specimen from Red Beach.

36. A red argillaceous sandstone with scales of mica.

Eastward from Verlegen Hock they entered Beverley Bay.

Specimens from Beverley Bay.

18. Granite, with flesh-red orthoclase-felspar.
19. Granite, with white orthoclase-felspar.
20. Granular quartz-rock.

They then entered Waigatz Strait, and moored in an extensive Bay, called in an old Dutch chart Treuenberg Bay, where they wintered, on the eastern shore, at a spot to which they gave the name of Hecla Cove. The depth of water was 13 fathoms, with a bottom of very tenacious blue clay. On the east side of the bay, they found beds of schistose quartz, nearly approaching to sandstone, and chiefly of a pale-red colour. Beds of clay-slate also occur, of a greenish-grey and brick-red colour.

Specimens from Hecla Cove.

21. Grey fine-grained quartz-rock with laminæ of silvery mica.
22, 23. Quartz-rock.
24. Granular quartz with mica.
25. White saccharoid limestone.
26. Laminated quartzose rock, interstratified with clay-slate.
27. Mica-slate with garnets.
28. Grey compact quartzose rock with a few scales of mica.
29, 30. Quartzose argillaceous slate, the laminæ having a shining surface, and exhibiting cleavage nearly at right angles to the bedding-planes.
31. Quartzose siliceous slate with much mica.
32, 33. Greenstone or diorite.
34. Red and grey variegated argillaceous sandstone.
35. A crust of peroxide of iron.

A specimen (No. 7) was sent, labelled "Foster's Island, Beachey Bay;" but no place by that name is mentioned in the 'Narrative.' It is a crystalline rock composed of hypersthene and felspar.

On every part of the northern coast on which they landed, they found drift-wood. Some of the trees had their roots attached, and were not less than 18 inches in diameter; all were of the Pine tribe.

2. *On the So-called* WEALDEN BEDS *at* LINKSFIELD, *and the* REPTILIFEROUS SANDSTONES *of* ELGIN. By CHARLES MOORE, Esq., F.G.S.

(Abstract.)

WHEN visiting the section at Linksfield, near Elgin, in the autumn of 1859, the author recognized a similarity of appearance between the shales and thin limestone-bands at Linksfield and those of the Bone-bed series (at the base of the Lias) at Pylle Hill, near Bristol, at Aust Passage and at Penarth, on the Severn, and at the Uphill cutting on the Great Western Railway. Giving in detail the sections at Pylle Hill, at Uphill, and at Linksfield, the author pointed out some close lithological resemblances, and stated that he recognized the "White Lias," the "Cotham Marble," the "Bone-bed," and the gypseous clay-bands of the south in the quarry at Linksfield. *Cyprides*, *Estheriæ*, remains of *Hybodus*, *Lepidotus*, *Acrodus*, and *Plesiosaurus*, *Mytilus*, *Modiola*, *Unio*, *Cyclas*, *Astarte*, *Ostrea*, *Paludina*, &c., from the Linksfield beds, were among the palæontological evidences which the author brought forward as supporting his correlation of the beds in question. The following are the detailed Sections.

1. *Section at Pylle Hill, on the Bristol and Exeter Railway, near Bristol.*

	ft.	in.
Close-grained grey stone, with *Modiola* ("White Lias"), the lowest band being the "Cotham Marble" or "Landscape-stone."		
Grey marl, passing into blue ...	4	0
Stone	0	8
Grey marl	0	6
Stone	0	6
Grey marl, passing into blue ...	5	0
"Bone-bed," with Fish-teeth, *Modiola Hillana*, *Avicula*, *Ostrea*, &c.	0	3
Blue marl	0	10
Greenish-grey stone	3	0
Blue marl	2	0
Grey stone	0	4
Blue marl	3	0

The last graduates into red sandstone and marls, which in this cutting are exposed to a depth of 30 feet.

2. *Section at Uphill, on the Great Western Railway, near Weston-super-Mare.*

	ft.	in.
Lower Lias, about	50	0
(*Trias.*)		
"Bone-bed"	0	2
Indurated shale	1	3
Gritty, grey, micaceous stone ...	0	7
Marl, with large nodules	5	0
Stone	0	2
Marl	2	0
Nodular stone	0	6
Marl	0	9
Nodular stone	0	3
Marl	0	6
Stone	0	2
Variegated marl	2	0
Rubbly stone	0	3
Indurated marl	1	0
Blue gritty sandstone	0	3
Grey marl	2	0
Soft gritty sandstone	1	2
Dark marl, passing into grey ...	1	4
Thin course of green stone	0	5
Marl	1	0
Dull-blue tufaceous marl	1	2
Light-grey stone	0	4
Marl	0	1
Conglomerate	0	1½
Marl	0	1
Grey stone, with traces of Fish-scales	0	6
Grey slaty marl	2	6

	ft.	in.
Concretionary grey stone, with small pebbles and probable traces of vegetables	0	7
Grey and yellow marl	0	6
Band of carbonate of lime	0	0½
Indurated grey marl	0	10
Compact grey limestone	0	11
Green marl	1	0
Coarse green limestone	0	3
Green marl	1	0
Red marl	0	7
Sandstone	2	10
Red marl	1	4
Red marl and thin courses of stone	2	0
Green and variegated marl	2	0
Red laminated marl	6	0
Red sandstone	0	4
Variegated marl, with concretions of calc-spar	1	0
Sandstone	0	5
Red marl	0	5
Sandstone	1	6
	48	10½

Red marls, with layers of gypsum, succeed, and continue to the base of the section.

3. In descending order, the section at Linksfield * shows (under the upper Till or Drift)—

	ft.	in.
1. Green clay. *Cypris* (rather sparingly). Teeth of *Hybodus*, and scales of *Lepidotus*	1	6
2. Grey stone. Small *Modiola*	5	0
3. Blue, variegated, and green clay. *Cypris* (rare). *Hybodus*. *Lepidotus*	1	6
4. Stone	1	8
5. Green clay. *Cypris*. *Estheria*. *Lepidotus*, &c.	0	10
6. Stone	0	10
7. Dark clay. *Cypris*. *Lepidotus*. *Hybodus*	0	10
8. Stone (="Bone-bed") †. Teeth and spines of *Hybodus minor*. Teeth, jaws, and scales of *Lepidotus*. *Sphenonchus Martini*, Ag. Teeth and vertebræ of *Plesiosaurus*, &c. Small Univalve and Bivalve shells. Remains of Plants	0	3
9. Blue clay. *Cypris*, abundant. Fish-remains, rare	4	0
10. Stone	1	4
11. Green marl (*Estheria* occurs in some of these lower beds)	0	9
12. Stone	0	10
13. Green marl	2	10
14. Stone	0	10
15. Green marl	2	0
16. Stone	0	8
17. Green marl	0	5
18. Boulder-clay	5	0
19. Cornstone	12	0
20. Reptiliferous Sandstones (?).		

The author next offered some observations on the red layer of clay, sand, and stones intercalated between the Linksfield shales and the cornstone; and, not accepting Capt. Brickenden's opinion ‡ of its having been thrust in by the action of ice against the escarpment during the formation of the Boulder-clay, he suggested that an early glacial period, contemporaneous with the Lower Lias, destroyed some of the lower shales and limestone of Linksfield, leaving their remnants imbedded in a red drift to be covered by the succeeding undisturbed deposits of the bone-bed series.

Mr. C. Moore next remarked that the Cornstone at Linksfield, on which all the above-mentioned beds rest, might possibly be of Triassic date, as he had observed on the flanks of the Mendips and elsewhere a stone, of a similar aspect, belonging to the Trias, and

* See also Mr. P. Duff's Section in his "Sketch of the Geology of Moray," pl. 3.
† See Mr. P. Duff's "Geology of Moray," p. 64, pls. 4 & 5.
‡ Quart. Journ. Geol. Soc. vol. vii. p. 289.

occasionally yielding remains of Reptiles and Fishes; to this rock the author refers the "druidical" stones of Stanton Drew.

Some observations on the discovery of reptilian and mammalian teeth near Frome, by the author, in a fissure containing a probably Triassic deposit,—on the possible relations of some of these to the *Reptilia* found in the Lossiemouth sandstone,—and on the probable Secondary age of the latter, concluded the paper.

April 18, 1860.

SPECIAL GENERAL MEETING.

It was resolved that the Evening-meetings of the Society on May 2nd, May 16th, May 30th, and June 13th be held at Burlington House, Piccadilly.

ORDINARY GENERAL MEETING.

Edward Brainerd Webb, Esq., C.E., 34 Great George Street, Spencer Herapath, Esq., 19 Sheffield Terrace, Kensington, and Owen Bowen, Esq., 4 Great Queen Street, Westminster, were elected Fellows.

The following communications were read:—

1. *On a* Well-Section *near* Gosport. By James Pilbrow, Esq.

[In a Letter to the Assistant-Secretary.]

The following is a section of the deep well and boring recently made under my direction (1858) for the Gosport Water-works Company, at Bury Cross, about one mile and a quarter west of the town. It is, I believe, the most carefully observed, as well as one of the deepest wells executed in that district, where the strata vary so much that the same stratum will scarcely be found with like characters at two places, though only a few hundred yards apart; and frequently the omission altogether of one or other of the strata shows that very considerable disturbing causes must have been in operation either at the period of the formation of these deposits or subsequently.

In the upper and middle portions of the stratum of sand noted in the section at from 33 feet 1 inch to 67 feet 3 inches, the fine series of perfect fossils occurred, of which a note is appended. Others occurred in the lower portion of this bed; and where it merged into the green sand below, which was dry and hard, the specimens became much fractured and very rotten.

Fossils were not again met with until the depth of 84 feet was reached, and from that to 95 feet. These were similar to the foregoing, but mostly fragmentary and mixed in masses with the sand. At from 95 feet to 104 feet, a few other fossil shells were also found.

A Section of the Strata near Bury Cross, Hampshire.

	ft.	in.	Depth of shaft. ft.	in.	Notes.
Alluvial soil	1	6	1	6	
Gravel	8	0	9	6	
Mottled clay	2	3	11	9	
Blue clay, with some sand and pyrites	15	6	27	3	Water at 25 ft.
Light sand, with pyrites and small shells	5	10	33	1	12 gallons of water per minute.
Sand and shells	34	2	67	3	Water increasing at 45 ft. 1 in. At 52 ft. more loamy and full of shells*.
Green sand	2	9	70	0	
Green sand (lighter)	5	0	75	0	
Light green sand	5	0	80	0	
Light sand	3	0	83	0	
Clay and sand	1	0	84	0	
Sand and shells	11	0	95	0	Compact and full of shells at 86 ft.
Sand, shingle, and shells †	9	0	104	0	
Laminated clay	2	9	106	9	
Blue clay and sand	11	6	118	3	
Black peat (woody)	4	6	122	9	
Stiff blue and green clay	16	0	138	9	
Blue clay and sand	12	6	151	3	
Dark sand and water	2	0	153	3	
Blue clay and sand	8	1	161	4	
Green sand	1	0	162	4	
Stiff blue clay	21	5	183	9	
Dark green sand, intermixed with clay, peat, and pyrites	18	0	201	9	
Green sand and water	20	6	222	3	
Blue clay and sand	49	3	271	6	
Sand and shells	1	0	272	6	
Blue clay and sand	27	6	300	0	At 290 ft. 6 in. hard blue clay; no trace of sand.
Blue clay and black pebbles	1	0	301	0	
Blue clay, crusty	0	9	301	9	
Light sand and water	26	0	327	9	
Sandy clay and black pebbles	1	3	329	0	
Hard clay	2	3	331	3	

The yield of water from this well is very copious, supposed to be little short of a million gallons *per diem*; but the means at present have only been equal to testing this to about 500,000 gallons at about 70 feet from the surface. The water rises and stands, when the engine is not pumping, at 9 feet from the surface of the ground.

* The following list of these fossils, exhibited to the Society by Mr. Pilbrow, has been drawn up by Prof. Morris, F.G.S.:—

Nummulina lævigata, *Lam.*
Turbinolia elliptica, *Brongn.*
Ostrea, small.
—— flabellula, *Sow.*
Anomia lineata, *Sow.*
Vulsella.
Pecten corneus, *Sow.*
Corbula Pisum, *Sow.*
—— costata, *Sow.*
Nucula similis, *Sow.*
Sanguinolaria Hollowaysii, *Sow.*
Cytherea elegans, *Lam.*
Cardita planicosta, *Lam.* Several specimens of different stages of growth. The largest has a group of small *Ostreæ* attached to it.
Natica.
Buccinum.
Turritella imbricataria, *Lam.*
—— terebellata, *Lam.*

† *Solen obliquus*, Sow., occurs in this bed.

The water has been analysed by Dr. Letheby, and reported to be remarkably pure; and, among other qualifications, to be superior to the Artesian well waters in the London Basin—even the best, such as the Royal Mint well, or that at Holt's Brewery, having only 3° of hardness after boiling: and it has no communication with the sea.

The sinking of this well occupied two years. Brickwork, with a bore of 10 feet in diameter, was carried to a depth of 25 feet. Cast-iron cylinders, with a bore of 7 feet in diameter, were carried to a depth of 110 feet. A bore-pipe with a diameter of 18 inches was carried to a depth of 326 feet 9 inches; and 25 feet was perforated.

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2. *On the* Presence *of the* London Clay *in* Norfolk, *as proved by a* Well-boring *at* Yarmouth. By Joseph Prestwich, Esq., F.R.S., Treas. G.S., &c.

The northward extension of the London Clay has hitherto been considered to have its limits in the southern part of Suffolk. Its lower beds outcrop near Ipswich; at Harwich it is only 23 feet thick; and, as from thence to Bawdsey near Orford, the rise is to the northward, the impression is given that the Eocene series ends under the Coralline Crag somewhere about Orford or Aldborough, and that further north the Pleiocene series reposes directly on the Chalk; such being in fact their superposition throughout North Suffolk and Norfolk wherever the base of that series is visible.

An exception, however, to this order has been proved by a well-boring at Great Yarmouth, which was brought to my notice by the Rev. John Gunn, F.G.S., of Irstead.

It appears that in the year 1840, the firm of Sir E. Lacon and Co., being desirous of obtaining a larger supply of water, had a shaft dug to the depth of 22 feet, and then a boring carried down to the depth of 597 feet, by Messrs. Clark of Tottenham. Unfortunately this spirited undertaking was not successful so far as the water-supply was concerned; but geologists are nevertheless indebted to Messrs. Lacon and Co. for having preserved a full record of the boring, and specimens of the strata penetrated, which have brought to light some geological facts of interest.

On either side of Yarmouth the cliffs consist of Boulder-Clay, with underlying sand- and gravel-beds, ranging for miles in a comparatively horizontal position. The town is situated on a bank of sand and shingle at the angle formed by the sea and the River Yare, the valley of which interrupts the cliffs for a distance of about five miles. Judging by the thickness of the beds between the Boulder-clay and the Chalk elsewhere in Norfolk, it might have been inferred that the latter passed under Yarmouth at a depth of from 30 to 40 feet, unless any unusually great scouring-out of the valley had worn a deeper channel at some very late geological period.

Specimens of the boring were taken with great care at every 10 feet or less of depth, and were duly noted and preserved; whilst a well-executed coloured section of the well records the general

features. I am indebted to Sir E. Lacon and Co. for the opportunity of inspecting this, and the interesting series of specimens. The following description of them I made on the spot, in company with Mr. Gunn and Mr. Rose.

One column gives the specimens as read off previous to my having formed any definite conclusion; and in another column is added the geological structure which the examination of the specimens in conjunction with the coloured section led me to surmise. From the nature of the work, the shells are necessarily small or fragmentary.

Depth. Feet.	*Nature of Specimens.*		
1 to 50	....	BLOWN SAND AND SHINGLE.	about 50 ft.
58	1. Coarse light-coloured sand, with 1 specimen of *Ostrea edulis*, 2 of the *Cardium edule*, 1 each of *Corbula nucleus*, *Tellina Balthica*, and *T. planata*.		
109	2. Light-grey clay with a few pebbles of quartz, fragments of *Cyprina Islandica*, 1 *Tellina*, and 1 fragment of *Pecten opercularis*.		
111	3. Yellowish shelly sand with fragments of small *Tellinæ*.		
113	4. Fragments of comminuted shells, none perfect.	RECENT ESTUARINE DEPOSITS.	120 feet.
123	5. Light-coloured shelly sands.		
150	6. Light-grey shelly sands.		
156	7. The same, coarser, with concretions and a few flints.		
158	8. Laminated micaceous grey clay.		
160	9. Light-brown clay.		
161	10. Grey clay and sand, with shells; *Tellina* (same as in No. 2), 1 fragment of *Mytilus edulis*.		
166	11. Grey clay, with undeterminable fragments of shells; 1 valve of *Balanus*.		
170	12. Light-brown clay and small light-coloured concretion (like those in the London Clay).		
180	13. The same, one concretion.		
190	14. Tough brown clay.		
200	15. The same, slightly greyer.		
210	16. The same, one concretion.		
220	17. The same, slightly variegated*.		
230	18. Brownish-grey clay.		
240	19. Dark-grey clay.		
240–50.	20. The same, with 2 lumps of iron-pyrites and 2 small calcareous concretions.		
250	21. Grey clay.		
260	22. The same, darker and more compact.		
270	23. The same, ,, ,,		
280	24. The same, ,, ,,		
291	25. The same, browner; iron-pyrites.		
294	26. The same, with wood and decomposing iron-pyrites.		
300	27. Brown clay.	LONDON CLAY.	310 feet.
309	28. Light-grey sandy clay.		
320	29. Greenish sandy clay.		
330	30. Streaked brown clay.		
340	31. Greyish-brown clay.		

* Possibly caused by the boring tool.

Depth. Feet.	Nature of Specimens.		
350	32. Micaceous sandy clay.	London Clay.	310 feet.
358	33. Same as 31.		
370	34. " 32.		
380	35. Brown sandy clay.		
389	36. Grey clay, with decomposing iron-pyrites.		
390	37. Brown clay.		
400	38. The same.		
410	39. Brown micaceous sandy clay.		
420	40. Brownish sandy clay.		
430	41. The same.		
440	42. Dark-brown sandy clay.		
450	43. The same, with soft green grains.		
460	44. Tough brown clay.		
470	45. The same.		
475	46. Fragments of soft septaria.		
480	47. Grey clay, with lignite.	Woolwich and Reading Series.	46 feet.
490	48. Tough brown clay.		
500	49. Streaky dark-grey clay.		
505	50. Grey clay and green sand.		
510	51. The same, more mixed.		
515	52. The same, with more green sand.		
520	53. The same, with less green sand.		
525	54. Pure dark-green sand.		
526	55. The same, more clayey and with small dark-green-coated flints.		
527–97.	56. Chalk with flints.	Chalk 57+	

This section is of interest for more reasons than one. In the first place, it shows how recent the immediate ground is on which Yarmouth stands, it being nothing more than blown dune-sands and beach-shingle.

2nd. Beneath the sand and shingle we have the opportunity (rarely offered) of tracing a complete section of a very recent estuarine deposit. It consists of 120 feet of tranquilly deposited sand and silt in alternating beds. Unfortunately, the shells being in such a fragmentary state, few species can be determined. I have been aided in these by Mr. Rose, of Yarmouth, who has carefully gone through all the specimens again, and made the necessary comparisons. A considerable portion of the fragments have evidently been washed out of the adjacent Crag, which at that time probably extended in exposed banks on either side of the old river-estuary. I do not, however, believe that any portion of the 120 feet belongs to the Crag itself; there is too much uniformity throughout the mass, and it is too argillaceous. The level of the adjacent Crag is higher; and there is no reason to suspect a depression in the London Clay anterior to the Crag-period coincident with the depression in the recent surface, or in the Chalk; and all the fragments are of such shells as might be washed out of the Crag, or are living as well as Crag species.

3rd. At the depth of 170 feet the beds change so suddenly, and the hand-specimen, with its small light-brown concretion, is so like an ordinary specimen of London Clay, that I at once noted its resemblance, but without at all suspecting the London Clay to be there. When, however, I passed from specimen to specimen with

like or very similar characters through a thickness of above 100 feet, I began to suspect that it was a mass of London Clay; and the examination of the remaining specimens strengthened that conviction. There were, it is true, no fossils (that, however, often happens in borings of the London Clay in the London district itself); but the characters of the beds were so uniform and so closely resembled the ordinary London Clay, and the small calcareous and phosphatic nodular concretions were so identical with specimens common in the London Clay of Essex and Kent,—and the whole is underlain by a seam of septaria, so usual in the Essex wells,—and these by a series of beds of green sand and clay with lignite, so characteristic of the beds between the London Clay and the Chalk (although they here present a modified type), that I have not the slightest doubt of this being a mass of true Lower Eocene strata *in situ*.

Such a circumstance renders it probable that a bed of variable thickness of London Clay may extend beneath the Crag between Orford and Yarmouth, and may possibly range as far north as Mundesley or Bacton.

This mass cannot extend far inland, as the Chalk comes at places to or near the surface along a line about ten to fifteen miles distant from the coast. From this line, as the Chalk dips eastward, the Eocene strata may probably set in, and, dipping also eastward, pass out under the bed of the adjacent German Ocean.

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3. *On some* FOSSIL FORAMINIFERA *from* CHELLASTON *near* DERBY. By T. RUPERT JONES, Esq., F.G.S., and W. KITCHEN PARKER, Esq., Memb. Micr. Soc.

[Plates XIX. XX.]

SEVERAL months ago, some clays (probably of Upper Triassic age) which had been brought to Messrs. Cubitt's Works from Chellaston, three miles south of Derby, were submitted to examination, and yielded some unexpected results, affording us a fine series of *Foraminifera*. The clays examined were red and blue in colour, and were obtained from the pits in which the alabaster occurs. The blue clay yielded abundance of *Foraminifera*; the red was barren.

About a pound of the blue clay was washed down. It yielded a considerable residuum (somewhat under ten *per cent.*) of fine sand, chiefly siliceous and subangular, together with some minute pyritic globules. There were two or three Otolites met with, some valves of *Entomostraca* (a species of *Cythere*), and several fragments of *Echinodermata* (minute plates and spines).

Of the *Foraminifera*, nearly one half consists of a variety of *Rotalia repanda* (*R. elegans*, Pl. XX. fig. 46). The individuals are very small, and are similar to those found living in the Mediterranean, in different places, at about 700 fathoms depth. Indeed it is a variety very common in warm seas, and ranges from 100 to 2000 fathoms. It is the *Rotalia Partschiana* of D'Orb. (For. Foss. Vienn. pl. 8. figs. 1–3),

W K Parker del. Geo West Lit

W.K. Parker del. Geo. West lith. W. West imp.

and is identical also with *R. elegans*, D'Orb. (Ann. Sc. Nat. vol. vii. p. 276. no. 54) and Soldani (App. Test. [or Sagg. Orit.] pl. 2. figs. Q. R).

The next most numerous group comprises the well-known forms which have been distinguished by the designations *Nodosaria, Dentalina, Marginulina, Vaginulina, Planularia, Frondicularia, Flabellina, and Cristellaria* (Pls. XIX. & XX. figs. 1–43). These are the chief members of the great Nodosarine genus.

The genus that is next in numerical force is *Nubecularia* (Pl. XX. figs. 48–56), a genus that has not yet been well worked out. Besides the varieties comprehended under the name of *N. lucifuga* by Defrance (Dict. Sci. Nat., Zool. pl. 44. fig. 3), we have here several long jointed forms, such as occur under certain conditions in company with tortuous and scale-like varieties in the mud of the Indian and other seas.

Polymorphina (Pl. XX. fig. 44), *Bulimina* (fig. 45), and *Lituola* (fig. 47) are represented in this clay by a few individuals of very familiar varieties, such as occur plentifully both recent and fossil.

Nodosarina (genus).—Individuals belonging to the subgenus *Nodosaria* occur fossil at Chellaston in a very simple state of growth; and others present us with numerous stages of development, so that we have two-celled, three-celled, four-, five-, and more-chambered individuals; straight and curved; smooth and ribbed; circular in section, oval, and compressed; of straight growth and oblique, with central and with lateral aperture. Indeed we can recognize amongst the many varieties, shells corresponding to those which have been named *Nodosaria* (*Glandulina*) *Glans* (Pl. XIX. fig. 7), *N. Radicula* (figs. 1–5), *N. humilis* (fig. 6), *N. Badenensis* (figs. 8, 9), *N. Raphanus* (fig. 10), and *N. lineolata* (figs. 11, 12).

Amongst those with more or less oblique chambers, we recognize *Dentalina brevis* (Pl. XIX. figs. 23, 24), *D. pauperata* (fig. 22), *D. communis* (figs. 25, 26), *Vaginulina Legumen* (figs. 27, 28), *V. strigillata* (figs. 29–35), *V. Dunkeri* (fig. 36), and *Planularia reticulata* (fig. 38). The compressed form of *Nodosaria humilis*, constituting a *Lingulina* (figs. 13–15), is abundant here, as it is also in the Lias, as we know from our own collections, and from Bornemann's "Lias-Formation von Göttingen." The form we refer to is the *Lingulina carinata* (D'Orb.), both smooth and striated. The gradations between these Linguline forms and *Frondicularia* are striking and abundant here, in both smooth and striated shells. The Frondicularian variety found here is chiefly the *F. striatula* of Reuss (figs. 16–18), together with a variety of *F. complanata* of Defrance (fig. 19). The gradations from *Frondicularia* to *Flabellina*, with a more or less spiral arrangement of the older part of the shell, are remarkable, and produce *Flabellina rugosa*, D'Orb. (figs. 20, 21). The chevron-chambered *Nodosarinæ* are subject to much irregularity of growth as regards the lateral extension of the chambers; nor are the *Dentalinæ* exempt from similar distortion of growth.

It is impossible to mark the exact boundaries which limit the *Vaginulinæ, Planulariæ*, and *Cristellariæ* of this fauna. Minute flattened individuals of *Cristellaria Cassis* (fig. 41) are linked by

various graduating forms with *Marginulina Sublituus* (fig. 37) and *Planularia Bronni* (fig. 40), on the one hand, and with *Planularia reticulata* (fig. 38) and *Pl. pauperata* (fig. 39) on the other.

Pl. pauperata is here indicated as a variety not previously recognized. It is a minute, subtriangular, flattened shell, consisting of six chambers, four of which are transversely broad; the two others (the oldest) are subglobular, and resemble the early cells of a *Nodosaria*. The shell is smooth, the septa are gently curved and sulcate; the aperture is distinctly marginal and produced. This is one of the simplest forms of the Cristellarian type. Although very minute (about $\frac{1}{200}$ in. in diam.), it closely assimilates in outline to the large Planularian *Cristellariæ* of the Subapennine tertiaries, which sometimes attain to $\frac{1}{12}$ in. in diam.

At first sight it might appear difficult to suppose that all the varieties, ranging from the simple *Nodosaria* to the nautiloid *Cristellaria* (figs. 1–43), should belong to only one species; but such an exceedingly wide range of variation is the rule in *Foraminifera*—a group of creatures extremely low in organization, and showing a licence as to their morphological laws, as great as any possessed by the lowest animals and plants.

Similar in shell-structure, the *Nodosarinæ* differ amongst themselves in their mode of growth chiefly as to the rectilinear or spiral arrangement of the chambers, as to the more or less excentric position of the aperture, and as to the flattening of the shell. In every gathering of *Foraminifera* rich in this group, the gradations of form are endless, presenting, however, certain more or less conspicuous varieties, which are conveniently separated as subspecific or varietal groups, and which have been considered by some to be of generic and specific value. Moreover each local fauna has its own set of varieties, which are often sufficient to serve as characteristic features of the fauna.

With the exception of *Flabellina rugosa*, *Vaginulina strigillata*, *Planularia reticulata*, *Pl. pauperata*, and *Pl. Bronni*, all the abovenamed varieties of *Nodosarina* occur more or less abundantly in the recent seas, as well as in tertiary and secondary deposits: nor are the excepted varieties without their representatives; for they do not differ in any essential character from many recent forms with which we are acquainted.

Polymorphina.—The well-known species *Polymorphina lactea* is represented in the clay from Chellaston by a very minute but characteristic individual (Pl. XX. fig. 44). It is a short tear-shaped shell, being of the variety known as *Guttulina communis* (D'Orb.). *Polymorphina* occurs also in the Lias, where it is represented by Mr Strickland's rather more elongate variety, *P. liassica** ; and it is continued to the present day in great varietal abundance.

Bulimina.—A cast of a minute *Bulimina* (fig. 45) resembling *B. Pyrula* of D'Orb. also occurs. It is not unusual to find the very thin-shelled small individuals of this species indicated by casts only

* Quart. Journ. Geol. Soc. vol. ii. p. 30.

in clays. This is the oldest-known of the *Buliminæ*: the genus extends to the recent time, and still presents similar varieties.

Rotalia.—In this clay we also find, as we have already stated, a very minute *Rotalia* (Pl. XX. fig. 46) in considerable abundance. It is of a conical form, its umbilical base varying from being flat, or even concave, to a convexity almost equal to that of the spire. The umbilicus is usually marked with a raised umbo, from which radiate five or six slightly curved limbate septal lines. The far more numerous short septal lines on the upper or conical surface are also limbate, as well as the margin of the whorls. Of the numerous varieties of *Rotalia* wearing these features, most of which belong to the *R. repanda* species, we select, as the closest representative of this fossil form, the *Rotalia elegans* of D'Orb., figured by Soldani. We have already mentioned that this is a deep-sea variety (p. 452).

Lituola.—A minute individual of the genus *Lituola* (Pl. XX. fig. 47), of the form that has been named *Spirolina agglutinans* by D'Orbigny, and *Spirolina irregularis* by Roemer, occurs in the Chellaston clay. This is the oldest-known specimen of the genus; it is an attenuate, crozier-shaped, simple-chambered, one-mouthed variety of the *Lituola nautiloidea* of Lamarck.

Nubecularia.—Of the curious Miliolitic genus *Nubecularia*, we have here numerous very minute individuals (Pl. XX. figs. 48–56). This genus has not hitherto been well studied. Blainville and Defrance grouped it with the zoophytes, and gave several characteristic figures in the Dict. Sc. N. (Zooph. pl. 44. fig. 3). Soldani has depicted numerous individuals in his great work 'Testaceographia,' placing them with the *Serpula*. We have found *Nubecularia* associated with other *Foraminifera* in very many recent sea-sands from shallowish water, and have been enabled to recognize their relations with the Miliolite group. These are very protean shells: in deep water they are neither common nor large, but in the Algæ-belt they attain the size of hemp-seeds and even of split peas; and, growing attached to sea-weeds, shells, and other bodies, they become scale-like, or resemble lichens, or, winding about stalks and fronds, they form ring-like incrustations, shooting off into irregular processes and forming grotesque cervicorn figures (*N. lucifuga*). Similar forms occur in abundance in some of the French tertiaries. From the Clam-shells of the East Indian seas, and from the *Strombus gigas* of the West Indies, we get minute rectilinear individuals of *Nubecularia*, with a spiral commencement (*N. Tibia*, var. nov.). An allied variety, without a spiral beginning, is shown by D'Orbigny's *Webbina rugosa* (For. Canar. pl. 1. f. 16–18; and For. Vien. p. 74. pl. 21. f. 11, 12). In several clays of the Oolitic formations, we have met with these elongate varieties attached to *Gryphææ*, &c.

All these Nubecularian forms have an opake shell, frequently arenaceous, and are composed of minute, tent-like, plano-convex chambers, the base often being more or less imperfect; the aperture is produced, oval, and often lipped, and becomes enveloped in the base of the new chamber, as in the true *Miliolæ*.

The foregoing varieties of *Nubecularia*, however dissimilar among

themselves, are all referable to the same specific type, which is sufficiently well represented by the *N. lucifuga*, Blainv., above referred to.

The specimens from Chellaston comprise about a dozen individuals (all very small), both of the rectilinear and the scale-like varieties. The latter (*N. lucifuga*, Pl. XX. figs. 52–56) are perfect, and from the extreme thinness of the shell on the flat or attached side allowing the pyritous casts to be seen, well exhibit the form and arrangement of the chambers. Of the straight specimens (*N. Tibia*) we have only fragments, the spiral portion being absent (figs. 48–51); they appear to have been attached by flattened portions of the dilated proximal end of the chamber, the long distal end being tubular.

Comparison with other Faunæ.—Taking the above-described group of *Foraminifera*, from the Alabaster-pits of Chellaston, as a fair sample of the marine microzoic fauna of the latest Triassic period, we have to compare it with the Rhizopodal faunæ of the Liassic and later periods, and with that of the present seas. The Upper Lias of Ilminster and the Lias of Göttingen are known to be rich in *Nodosarinæ*; at Stockton in Warwickshire the Lias clay, several pounds of which we have worked out with great care, yields abundance of the *Nodosarinæ* of the same species as, but of different varieties to, those of Chellaston, associated with *Quinqueloculina*, *Trochammina*, *Rotalia ammonoides*, and a variety related to *R. elegans*.

In some of the clays of the Oolites we find not dissimilar faunæ. This is the case with two clays of the Middle Oolite (from near Peterborough), in which, besides the *Nodosarinæ*, *Nubecularia*, *Trochammina*, *Lituola*, and *Rotalia elegans*, we have fine specimens of *Verneuilina* equal in size to those of the Chalk. In the Oxford clay a similar group of *Nodosarinæ* occurs together with *Lituola*, *Nubecularia*, *Trochammina*, *Orthocerina*, and *Rotalia elegans*. The Kimmeridge clay yields also the *Nodosarinæ* in abundance, *Nubeculariæ*, *Trochamminæ*, *Polymorphinæ*, and *Rotalia elegans*, with *Bulimina* and numerous small forms of *Textularia*. The Gault and the Chalk abound with the *Nodosarinæ* and all the other forms above mentioned, with the addition of *Globigerina*, *Valvulina*, and some others.

Among the Tertiary deposits, a Pliocene clay from S. Quirico, Tuscany, presents a fauna most nearly allied to that of the Chellaston clay in hand; but it differs characteristically by the great abundance of *Globigerinæ* and *Nonioninæ*. The recent deposits most like that of Chellaston are grey muds from the western part of the Mediterranean at about 750 fathoms, having abundance of minute *Rotaliæ elegantes*, small thin-shelled *Buliminæ*, and delicate *Nodosarinæ* of various conditions of form; but these species are almost masked by the extreme abundance of well-developed *Orbulinæ* and *Globigerinæ*, and other *Rotaliæ* besides *R. elegans*. A sounding off Lisbon at about 700 fathoms, and one off Cape Finisterre, yielded somewhat similar results, the former presenting us with a form very rare in the recent state, namely, a *Frondicularia*.

The annexed Table gives a synopsis of the different Faunæ, and serves as an explanation to Plates XIX. and XX., in which the specimens are highly magnified.

Table of the Species and Varieties of the Fossil Foraminifera from Chellaston, compared with those of other Faunæ, Fossil and Recent.

				Chellaston.	Liassic.	Jurassic.	Cretaceous.	Tertiary.	Recent.
Pl. XIX.	Figs.	1 – 5.	Nodosaria Radicula, Linn. Syst. Nat. 1164. 285	*	*	*	*	*	*
—	—	6.	—— humilis, Roem. Nordd. Kreid. p. 95. pl. 15. f. 6.	*	*	*	*	*	*
—	—	7.	—— Glans, d'O. Ann. Sc. N. vii. 252. 2.	*	*	*	*	*	*
—	—	8, 9.	—— Badenensis, d'O. For. Foss. Vien. p. 44. pl. 1. f. 48, 49	*	*	*	*	*	*
—	—	10.	—— Raphanus, Linn. Syst. Nat. 1164. 283	*	*	*	*	*	*
—	—	11, 12.	—— lineolata, Reuss, Böhm. Kreid. I. p. 27. pl. 8. f. 8	*	*	*	*	*	*
—	—	13–15.	Lingulina carinata, d'O. For. Canar. p. 20. pl. 1. f. 13, 14	*	*	...	*	*	*
—	—	16–18.	Frondicularia striatula, Reuss, Böhm. Kreid. I. p. 30, II. p. 107. pl. 8. f. 23	*	*	*	*	*	*
—	—	19.	—— complanata, Defr. (var.) Dict. Sc. Nat. Conch. pl. 14. f. 4.	*	*	*	*	*	*
—	—	20, 21.	Flabellina rugosa, d'O. Mém. Soc. Géol. Fr. iv. p. 23. pl. 2. f. 4–7	*	*	*	*	*	var.
—	—	22.	Dentalina pauperata, d'O. For. Foss. Vien. p. 46. pl. 1. f. 57, 58	*	*	*	*	*	*
—	—	23, 24.	—— brevis, d'O. For. Foss. Vien. p. 48. pl. 2. f. 9, 10	*	*	*	*	*	*
—	—	25, 26.	—— communis, d'O. Mém. Soc. Géol. Fr. iv. p. 13. pl. 1. f. 4	*	*	*	*	*	*
—	—	27, 28.	Vaginulina Legumen, Linn. Syst. Nat. 1164. 288	*	*	*	*	*	*
—	—	29.	—— strigillata, Rss. (double and distorted specimen) ... }	*	*	*	*	var.	
Pl. XX.	Figs.	30–35.	—— strigillata, Rss. Böhm. Kreid. II. p. 106. pl. 24. f. 29 }						
—	—	36.	—— Dunkeri, Koch, Palæontographica, i. p. 172. pl. 24. f. 4	*	*	*	*	*	*
—	—	37.	Marginulina Sublituus, d'O., Sold. Testac. p. 104. f. F. G.	*	*	*	*	*	*
—	—	38.	Planularia reticulata, Corn. Mém. Soc. Géol. Fr. 2 sér. iii. p. 253. pl. 4. f. 1–4	*	*	*	*	...	*
—	—	39.	—— pauperata, J. & P. (See above, p. 454)	*	...	*	...	...	*
—	—	40.	—— Bronni, Roem. Nordd. Kreid. p. 95. pl. 15. f. 14	*	*	*	*	*	*
—	—	41.	Cristellaria Cassis, F. & M. Test. Micr. p. 95. pl. 17. f. *a–l*.	*	*	*	*	*	*
—	—	42, 43.	—— rotulata, Lam. Ann. Mus. v. 188. 3; viii. pl. 62. f. 11	*	*	*	*	*	*
—	—	44.	Polymorphina lactea, Walk. Test. Min. p. 2. pl. 1. f. 5	*	*	*	*	*	*
—	—	45.	Bulimina Pyrula, d'O. For. Foss. Vien. p. 184. pl. 11. f. 9, 10	*	...	*	*	*	*
—	—	46.	Rotalia elegans, d'O., Sold. Sagg. Orit. pl. 2. f. Q. R.	*	...	*	*	*	*
—	—	47.	Lituola agglutinans, d'O. For. Foss. Vien. p. 137. pl. 7. f. 10–12	*	*	*	*	*	*
—	—	48–51.	Nubecularia Tibia, J. & P. (See above, p. 455.)	*	...	*	...	...	*
—	—	52–56.	—— lucifuga, Defr. Dict. Sc. Nat. Zooph. pl. 44. f. 3	*	...	*	*	*	*

Conclusion.—Having thus pointed out that, judging from these specimens obtained at Chellaston, the minute *Nodosarinæ* and other *Foraminifera* of the Triassic period have continued to exist through the intermediate ages to the present day without losing any of their essentially specific features, we will observe that the *Nodosariæ* are present in rocks of still greater age than the Trias—namely, the Permian and Carboniferous, and probably even the Lower Silurian. *Nodosariæ* and *Dentalinæ* abound in some of the Permian limestones of Durham and the Wetterau in company with *Textulariæ. Nodosaria* occurs also in the Carboniferous Limestone of Ireland, according to M'Coy; and the green sand of the Lower Silurian series near St. Petersburg has yielded to Ehrenberg casts of chambers something like those of *Dentalina*, together with unmistakeable casts of Textularian and Rotalian shells. We may remark, too, that the *Fusulina* of the Russian, North American, and Arctic Mountain-limestone carries back the pedigree of the *Nonionina*-group to the palæozoic periods, and that it is accompanied with other *Foraminifera* of known types, amongst which the *Nummulina* is not absent. This last-named type has rare representatives in the Lias and the Oolite; it acquired great potency in the Tertiary seas, and is not extinct now.

Altogether we have here some remarkable instances of the persistency of life-types among the lower animals. Though the specific relations of the Palæozoic *Foraminifera* require further elucidation, we feel certain that the 6 genera represented in this Upper Triassic clay of Chellaston by about 30 varieties stand really in the place of ancestral representatives of certain existing *Foraminifera*, that they put on their several subspecific features in accordance with the conditions of their place of growth, just as their posterity now do, and that although we have in this instance met with only the minute forms of a 700-fathoms mud-bottom, yet elsewhere the contemporaneous fuller development of these specific types may be found by careful search in other and shallower-water deposits of the Trias period.

May 2, 1860.

The following communications were read:—

1. *On the* Physical Relations *of the* Reptiliferous Sandstone *near* Elgin. By the Rev. W. S. Symonds, F.G.S.

[This paper was withdrawn, by permission of the Council.]

(Abstract.)

Referring to Sir R. Murchison's sections of the Elgin district, published in the Quart. Journ. Geol. Soc. No. 59, pp. 424 and 428, which show a conformable sequence of strata from the Old Red Sandstone of Foths to the yellow sandstone and cornstone of Lossiemouth and Burgh Head, the author first stated that the siliceous marly rocks, or so-called "cornstones" of Glassgreen, Linksfield,

Spynie, Inverugie, and Lossiemouth are in reality very dissimilar to the cornstones of Foths and Cothall; and he then pointed out the improbability of the so-called cornstone of Glassgreen continuing to dip north-westwardly under the sandstone of the Quarry-wood Ridge, especially as near Linksfield it is, at different spots, seen to dip away from that ridge. Evidence also of a break in the strata at the Bishop Mill quarries was advanced to show that the sandstone beneath this "cornstone" (presumed to be the Reptiliferous sandstone) is probably brought by a fault against the lower or Holoptychian sandstone, which latter towards Spynie the author thinks is surmounted by the Reptiliferous sandstone, and this last conformably by a marly siliceous rock or so-called "cornstone."

Beyond Spynie Loch, northward, the author supposed that another fault had again brought up the sandstone with *Stagonolepis* and *Hyperodapedon* at Lossiemouth. Beyond this a cornstone-like rock is again seen to cover the sandstone.

The author then referred to the probable Liassic and Triassic character of the shales at Linksfield, and dwelt upon the suggestion that had been offered as to the probability of the layer of boulder-clay beneath the shales having been due to the mass of shales being a portion of a cliff in the glacial period, and having then slipped from a higher level. Regarding these shales as having been removed merely by a slip from their original site, and as conformably overlying the calcareo-siliceous rock and sandstone beneath, Mr. Symonds expressed his belief that this sandstone, shifted by a fault against the Holoptychian sandstone at Quarry-wood, must be the Reptiliferous sandstone and of Triassic age. Lastly he remarked that the pebble-beds and sandstone, track-marked and rippled, of Burgh Head are far more like the Triassic conglomerates of England than like the Old Red rocks of Cothall and Foths.

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2. *Notice of the* Discovery *of* Two Bone-caves *in* Northern Sicily. By François Anca, Baron de Mangalaviti.

(In a Letter* to Dr. Falconer, F.G.S.)

Since you left Sicily, I have continued my palæontological researches, and I am happy in having discovered two bone-caves previously unknown. One of these is at Monte Gallo, at the western extremity of the Bay of Palermo, and is situated at an elevation of 160 feet above the sea-level; the other is situated near the village of Acque Dolci, at the foot of Monte San Fratello, in the north of Sicily, and is 214 feet above the sea-level.

These caves, especially the last, are very rich; and, what will astonish you, they contain a prodigious quantity of bones of *Carnivora*, including perfect jaws armed with molars and canines. I have collected also two molars and a tusk of *Elephas*, teeth and bones

* Dated "Palermo, March 12, 1860."

of *Hippopotamus* (of the two species, I believe, determined by yourself). Altogether, remains of the following were met with:—

Hippopotamus; two species.	Cervus (two species?).
Elephas antiquus.	Canis.
—— Africanus.	Ursus.
Sus scrofa?	Hyæna.
Equus.	Felis.
Bos; two species.	Lepus. And others.

Having this large group of genera, we may say that we have recovered in this cave an entire fossil Sicilian fauna.

I have also found in these two caves a large quantity of flint implements ("de silex en armes"); and it is remarkable that we do not generally see them but where there are great deposits of bones of Deer,—never otherwise. Lastly there occur coprolites of Carnivores, and another kind of coprolite, which, I suppose, belonged to Herbivorous animals.

I have been fortunate also in detecting teeth of Carnivora in the Cave of Olivella ("la grotte de l'Olivella").

The necessity of having means of comparison at hand induces me to prosecute the study of these cave-bones at Florence, where I shall have the assistance of M. Meneghini. Afterwards I hope to publish the results of the exploration of these caves, and to describe them and the more interesting of the objects obtained.

May 16, 1860.

Frederick Wollaston Hutton, Esq., Lieut. 23rd R. W. Fusileers, Staff College, Sandhurst; John James Lundy, Esq., Primrose Bank, Leith; R. Farmer, Esq., The Hill, Hornsey; William Drury Lowe, jun., Esq., Locko Park, Derby; Arthur Beevor Wynne, Esq., of the Geological Survey of Ireland; and James Wyatt, Esq., Bedford, were elected Fellows.

The following communications were read:—

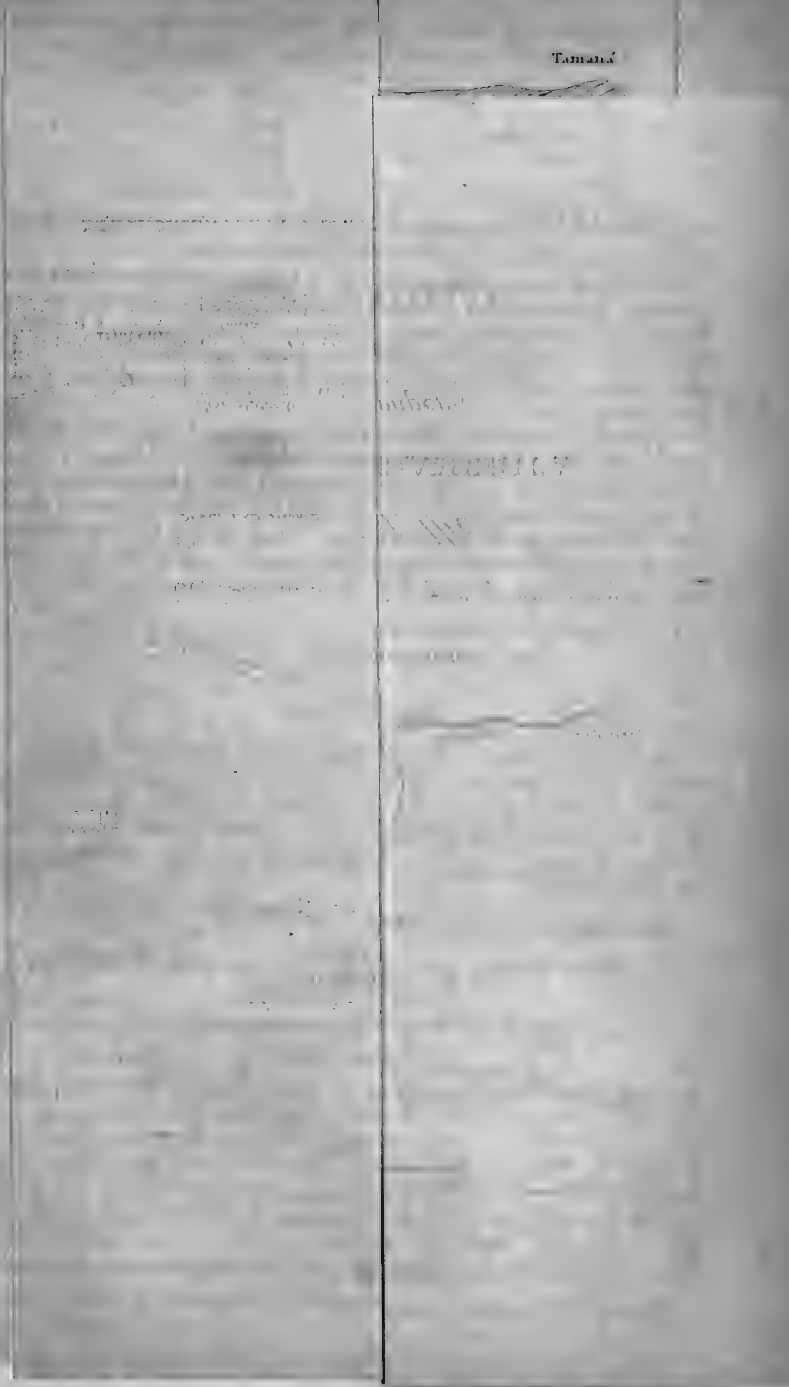
1. *On the* Geology *of a Part of* Venezuela *and of* Trinidad. By G. P. Wall, Esq.

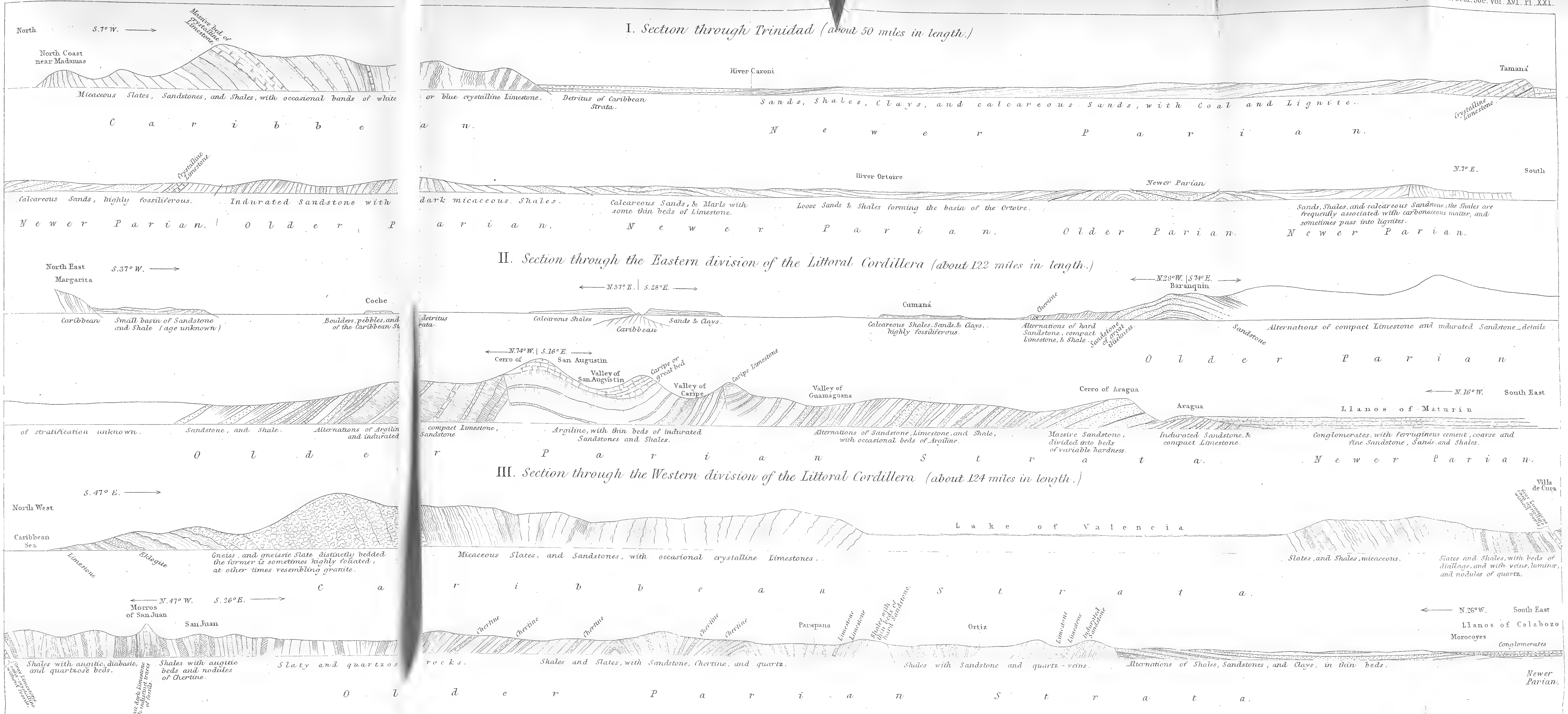
[Communicated by Sir R. I. Murchison, V.P.G.S.]

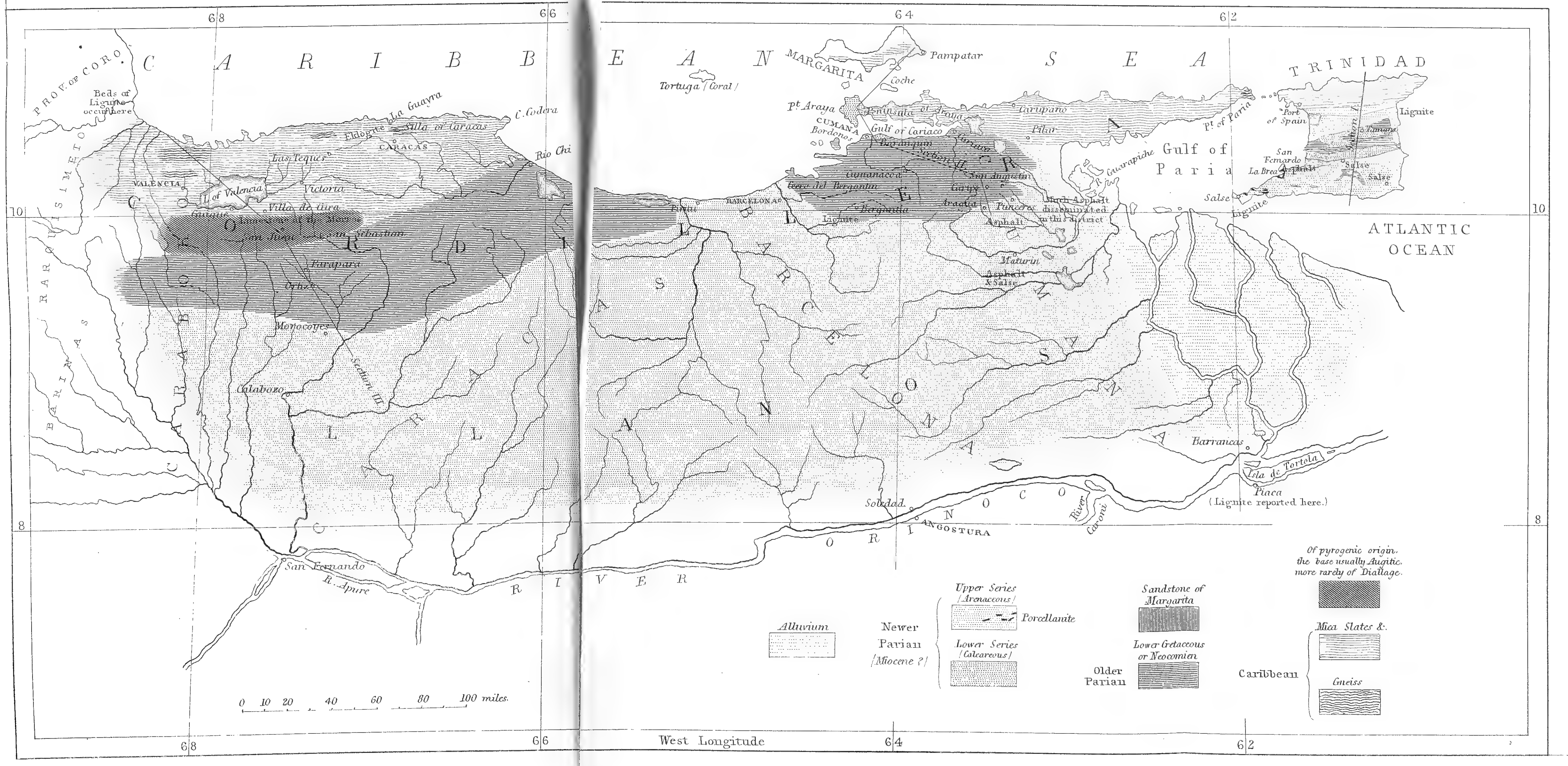
[Plate XXI.]

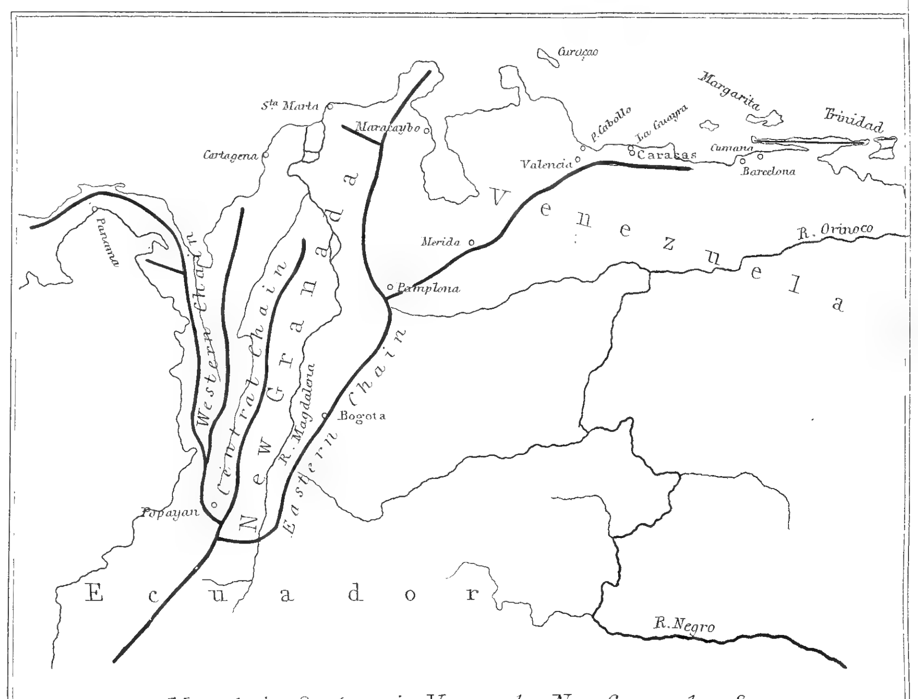
For our earliest distinct notions of the physical conformation and geological structure of this portion of the South American continent, we are indebted to the researches of that illustrious observer, Humboldt, who, on his visit to equinoctial America (1799), first landed on the coast of Venezuela, and prosecuted during a period of sixteen months a series of investigations in several departments of that State, thus rendering the most essential service to all subsequent travellers; for whilst some of his conclusions must be mo-

out 50 miles in length.)









Mountain System in Venezuela, New Granada, &c.

Maps and Sections of the NORTHERN PART OF SOUTH AMERICA

to illustrate Mr. G. P. Wall's paper

ON THE GEOLOGY OF

VENEZUELA & TRINIDAD.

1860.

Engraved by J.W. Lowry.

dified or rejected in accordance with the advance of science during the last sixty years, yet many of the results at which he arrived form a permanent addition to our knowledge, and will be verified by each of his followers.

A quarter of a century later, the French chemist Boussingault visited the same territory, and executed a number of researches, less general, but more detailed, and relating especially to the composition of the thermal waters and the distribution of the natural asphaltum.

The year 1841 witnessed the publication of the labours of Colonel Codazzi on the physical geography of Venezuela*, including a series of maps prepared from the topographical surveys and measurements conducted by him during more than ten years. This is an especially important work for the geological inquirer, furnishing him with many of the data so essential to the accuracy of his observations. It is not only the execution of these maps, though numerous and faithful, but also the precision with which the external features, the resources, and capabilities of the various regions are determined, that confers so high a value on this summary,—a value only to be duly appreciated by those who have traversed the country, and can realize the difficulties attending the performance of such labours, which, at the date of their publication, were quite exceptional, no similar compendium then existing for any other South American province.

Although that continent, possessing a magnificent system of rivers, and colossal mountain-chains, and a vegetation of the most varied and interesting description, presents unsurpassed attractions to the scientific explorer, yet it is to be apprehended that many years must elapse before our knowledge will partake of that precise and positive nature which already attaches to the investigations conducted in several much more recently settled countries. The constant political disturbances which agitate the South American Republics keep the various States in such an impoverished condition as to render their governments unable to support any regular scientific organization. Under these circumstances, we may long be dependent for the extension of our information respecting these regions on the mere casual visitor or resident, who, having but limited resources in a field so vast, finds himself reduced to contend with difficulties frequently beyond the power of individual effort to control or overcome.

North of the Orinoco, the principal inequality in the surface of Venezuela consists of a massive and elevated mountain-range known as the Littoral Cordillera.

To ascertain the origin of this striking physical feature, it is necessary to refer to the main chain of the Andes, which, a little north of the frontiers of Ecuador and New Granada, divides into three great ranges (see Pl. XXI.). Of these, the western follows the contour of the coast towards Panamá; the central continuing to the north in the direction of Carthagena; whilst the eastern, assuming a north-eastern course after passing Bogotá and originating a power-

* Geografia Fisica de Venezuela: Paris, 1841.

ful branch which terminates in the snowy mountains of Santa Marta, enters the territory of Venezuela by the mountainous region of Méridá, which comprises elevations of over 14,000 feet. On approaching the coast, under the tenth parallel, the direction changes to east, and so continues for 8 degrees, forming the southern boundary of the Caribbean Sea, and terminating at the eastern extremity of Trinidad.

The observations on which this notice is founded only extend to that portion of the Republic north of the 8th degree (corresponding for a considerable distance with the position of the Orinoco) and east of the 69th meridian, including, consequently, merely that section of the Cordillera last enumerated, and adjacent to the sea (Pl. XXI.).

In this distance the mountain series is twice interrupted: first by the great indentation of the coast in the province of Barcelona, dividing it into an eastern and western range; and secondly, by the Bocas or exit of the Gulf of Paria, which separates the third or insular portion.

The most ancient rocks the existence of which has been established comprise a series of micaceous and siliceous schists, the former especially presenting a great multiplicity of aspect, the mica passing from silvery white to the darkest shades, and from an extreme abundance to an almost entire suppression; secondly, of sandstones, in which the grains are coarse and accompanied with flakes of mica, or fine and free from the latter mineral; thirdly, of shales, occasionally ferruginous, sometimes micaceous, and often carbonaceous. (See Sections, Pl. XXI.)

These various rocks seem to have experienced a segregation or concentration of part of the siliceous material originally disseminated throughout the strata, since the silica occurs in layers—in lenticular or nodular forms, usually of great irregularity, but with a constant tendency to occupy the directions of bedding and foliation. The thickness of these quartzose masses (often only equalling the slightest film) may attain from 4 to 6 feet of thickness, evidencing the magnitude of the scale on which this process has operated.

White or blue limestones, generally crystalline, more rarely compact, are also members of the same series. By the association of argillaceous matter and mica, they become calciferous schists. The thickness of the limestones varies from a single inch to hundreds of feet; but the more massive beds are probably restricted to Trinidad, as they were not observed on the mainland.

A much rarer mineral aggregate, consisting of a base of smaragdite with crystals of garnet (and consequently a species of eklogite), occurs near Caracas and at Cambure, N.W. of Porto Cabello. It is distinctly stratified, and by the association of mica (scarcely ever entirely suppressed) passes into granatiferous schist.

An important variation in the nature of the series arises from the presence of gneiss, which prevails especially at the Point of Paria (the Scylla of Caracas) and between the lake of Valencia and the coast. It is difficult to establish any relations of age or sequence with the schists. The circumstances are rather those of alternation—a number

of schistose beds succeeding a series of gneissic, which are again replaced by the latter. The transition, occasionally gradual, is more usually sudden or abrupt. Generally the conditions may be defined as those of a schistose region traversed by gneissic zones. The latter rock is ordinarily foliated, but also occurs without the slightest parallelism of the constituent substances, or tendency to cleave in any particular direction. Even where the arrangement of the minerals is as irregular as that of granite, it is still bounded at certain intervals by distinct planes, the equivalents of the surfaces of the different beds.

Amongst the rarer substances existing in this group, garnets are the only earthy minerals not highly exceptional; and even these were merely observed in the more crystalline portions.

Gold is disseminated in the gneiss west of Valencia, but in quantities quite inappreciable to the senses. On treating the débris proceeding from the degradation of this rock, the yield, in extreme cases, has amounted to an ounce per week for one person.

At Las Tegues, 20 miles west of Caracas, the schists are impregnated over a considerable area with the sulphuret and carbonate of copper, which are associated in small quantities with the masses of quartz, or spread out between the laminæ of the strata. Nothing resembling an accumulation or mineral deposit appears to exist.

Argentiferous lead-ore has been worked on a small scale near Carúpano, and offers deposits of two different descriptions: the first of a bunchy irregular nature, with a slight proportion of silver (30 to 40 oz. in the ton); and secondly, where the metallic substances seem to be located in true veins of no great width, the ore is much rarer, contains a higher percentage of silver, and is associated with a ferruginous gangue.

The whole formation exhibits great disturbance and contortion, and constitutes the northern portion of the Cordillera. Forming for so great a distance one of the boundaries of the Caribbean Sea, it may be provisionally distinguished as the 'Caribbean System.' The strike is ordinarily E. and W., or parallel with the coast, but with local variations of 30°–40° N. of E. and S. of W. In the western range it occupies a band having a breadth of thirty miles, rising to a height of 8000 feet, and furrowed by longitudinal depressions; whilst in the eastern portion the valleys are transverse, and the breadth of the chain is restricted to ten or twelve miles, and the elevations to 3500 feet.

Another group of strata contributing still more largely to the formation of the Serranía, or hilly region, is on many accounts highly interesting and remarkable.

The most important members consist of sandstones varying from a mere layer to many hundreds of feet, and presenting permanent mineral and physical characters. It is often difficult to distinguish the separate elements, a condition which is accompanied with a high degree of induration,—properties evidently due to a siliceous cement precipitated around the constituent grains, a process which must have very generally operated in the consolidation of these

strata*. The limestones are hard and compact, containing in certain localities vast quantities of fossil remains, the substance of which is often replaced by crystalline spar, the form more or less obliterated, and so intimately associated with the mass of the rock as rarely to admit of separation. Occasionally limited to a few feet, the thickness may attain 100 feet, and amounts to even 700 or 800 feet for the great bed of Caripe, in which the grotto so minutely described by Humboldt is situated. Shales are largely represented, generally dark, containing a few flakes of white mica, and thin seams or layers of the sandstone above-described. In the western division of the mountains they experience a great development, and, assuming a partial induration accompanied by a fissile structure, often closely resemble clay-slates. A species of rock prevailing extensively in some localities, especially at Caripe and in Trinidad, has been provisionally termed *Argilline*, since it contains 85 *per cent.* of clay, and only about 3 of carbonate of lime: the colour is white or light-yellow, and the specific gravity usually slight, on account of the porous structure. It is sometimes jointed, producing a division into rhomboidal fragments, and presents a certain degree of induration. The beds are often of considerable vertical extent, and contain thin layers of the sandstone, or, more rarely, of the limestone.

The term *Chertine* is applied to strata presenting a sufficient resemblance to chert, but, in place of occupying laminæ in the limestones, forming independent beds 70 to 80 feet in thickness and divided into layers not exceeding 15 inches each: the texture is at times quite vitreous†. They are especially prevalent in the more shaly portions of the series (west of Barcelona).

The sequence of the members of this great system would probably be determined without difficulty by an observer possessing sufficient leisure; but the data on which these remarks are founded can only furnish obscure indications on this subject. Thus, from Aragua, in an ascending order (Pl. XXI. Sect. 2), we have the sandstones of the adjacent Cerro; alternations of limestone, sandstone, and argilline; then powerful beds of the latter, and finally the Caripe limestone,—representing on the whole certainly not less than 7000 or 8000 feet.

Probably the sandstones of Aragua and Baranquin, on opposite declivities of the Cordillera, are the same, as the thickness is about 1200 feet in either case, and they exhibit a similar succession of

* According to M. Cordier and some of the French geologists, the siliceous cement of sandstones is hydrated, soluble in acidulated waters, and, when the pores are entirely filled, may amount to one-third of the mass, then forming the variety known as *grès lustré*. If this view is correct, it will conveniently explain several facts observed in Venezuela.

† Since the text was written, we find that this rock and the slaty shales have already been mentioned as occurring in the Cretaceous formation of Northern Venezuela (Senft, 'Die Felsarten,' pp. 155 & 160, who quotes Karsten),—the first as siliceous schist (Kieselschiefer), and the second as clay-slate. We regard M. Cordier's term of "*phyllade*" for argillaceous slate of whatever age, as a happy invention and quite applicable in the case in question. The other substance belongs to the series which he classes as "*phthanite*," consisting of extremely fine siliceous with a little foreign matter.

hard and softer layers. A massive limestone forming the heights south of Cariaco, may correspond to the Caripe stratum; this supposition, however, did not admit of verification.

With regard to the distribution, west of the province of Barcelona this formation forms a hilly band, rarely less than 30 miles in width, not comprising elevations of more than 4000 feet, and consisting of a great repetition of thin layers or beds. To the east, on the contrary, the members are frequently of colossal proportions, and the principal summits much more elevated, attaining, for the Cerros de Srimniquiri, de Tionía, de San Augustin, and del Bergantin, respectively, 7149 feet, 7146 feet, 6000 feet, and 5784 feet. The extreme breadth varies from 35 to 40 miles.

In Trinidad a narrow belt of the system traverses the centre, and small fragments occur in the southern localities of the island. The elevations are limited to 900 feet.

The sections attached to this notice will suffice to express how intensely the formation has been disturbed. The trend is usually E. and W., or parallel with that of the "Caribbean System;" but there are frequent exceptions, the deviation amounting even to 45°, with a N.E. strike; in Trinidad it is almost constantly 20° N. of E.

As already stated, the fossils can rarely be separated from their matrix; fortunately a few specimens sufficiently characteristic were obtained at Bourdones, near Cumaná, and are considered by Mr. Etheridge as certainly belonging to the Cretaceous period*. Whether this formation, like the extensive deposits of New Granada, is of Neocomian age, must be determined by future researches. First observed near the gulf dividing Trinidad from the main, and the geological position being uncertain, it was distinguished in the 'Survey of Trinidad' as the "Older Parian System,"—a term which is retained in the present notice.

The relations of junction of the two preceding formations remain extremely obscure. In Trinidad they are completely concealed by more recent deposits; in the eastern chain the Gulf of Cariaco intervenes for a considerable distance; and between the village of that name and Carúpano the surface is covered with so dense a forest, that no proper sections could be found. In the western Cordillera an entirely new element is introduced, greatly complicating the problems of junction, and consisting of beds and matter of pyrogenic origin,—apparently interstratified with the members of the two systems, and assuming either a crystalline aspect or affecting a granular form, as though derived from the previous trituration of the component material, and finally so associated with the particles of the regular sedimentary members as essentially to modify their appearance, and to invest them with the most embarrassing characters. In the southern portion of the district the nature of this material is augitic, with an uncertain equivalent of felspar, and consequently forming, according to the subordinate properties, varieties of the diabasic type; whilst in the northern section the base is more generally diallage, thus originating aggregates often closely resem-

* *Trigonia*, somewhat like that of D'Orbigny's *T. Boussingaultii.*

bling serpentine. The siliceous strata of this region seem to have been especially affected, since they are frequently veined with vitreous quartz and present their joints coated with crystals of that substance, indicating the solution and re-precipitation of silica. The result of this intercalation of foreign elements is to obliterate the distinctive characters of the two formations, and to render it difficult to determine where one commences and the other ceases. The ten or twelve miles over which this uncertainty prevails was twice examined, but without satisfactorily solving many of the difficulties. In Pl. XXI. Sect. 3, the circumstances are represented as accurately as could be ascertained; the place of junction is probably at the point marked J, a short distance north of Villa de Cura,—as the position, hitherto inclined, becomes suddenly vertical, which is accompanied by a variation of aspect, slight indeed, but still perceptible on minute inspection.

The Morros of San Juan, so named from their castellated appearance, are formed of a grey limestone, compact or subcrystalline, of considerable thickness, and, from the almost obliterated vestiges of fossils, evidently a member of the "Older Parian" formation. It is perfectly vertical in position, and, rising suddenly in the centre of the igneo-sedimentary district from the rounded surface of the subjacent hills, in rugged, rocky precipices, and traversing the country in a narrow elevated ridge, offers a natural object of considerable interest.

At the south-eastern extremity of the Island of Margarita, there is a small basin of sandstones and shales, 600 to 800 feet thick, in which no fossils were detected, nor do they present any mineral features serving for identification with either the preceding or following series,—forming, perhaps, an intermediate term, of which other fragments may be discovered on further investigation. The sandstone is sufficiently indurated to have formed a good material for the construction of the old Spanish fort at Pampatar. An angle of 35° indicates the limit of the disturbances experienced.

The "Newer Parian" formation has been more completely studied in Trinidad*, where it consists of a lower (calcareous) and an upper (arenaceous or shaly) series, by no means clearly distinguished one from another, and rarely presenting the entire development in the same locality. The inferior portion is sometimes composed of limestone, often with crystalline texture, or of marls containing subordinate calcareous beds, which are succeeded by calcareous sands and shales. The superior section comprises an alternation of loose sands with carbonaceous shales and occasional conglomerates. On the mainland the calcareous series was only noticed at Cumaná, and on the peninsula of Araya; the superior division, on the contrary, occupies an enormous space, as the *llanos* or grassy plains of Venezuela are entirely formed of conglomerates, sandstones, &c. referable to this group. The former are especially prevalent, and include numerous rolled fragments of the indurated members of the "Older Parian," which forms the northern limit of the *llanos*, and which,

* See Memoir, No. 1, of Geological Survey of the West Indies.

already elevated into the great range, was undergoing extensive degradation during the tertiary epoch. The carbonaceous matter associated with this upper group of the formation sometimes becomes so abundant as to afford a fuel, admitting of exploitation: lignitic deposits of this nature exist on the eastern coast of Trinidad, near Piaco on the Orinoco, and in the provinces of Barcelona and Coro.

The only reliable data for estimating the thickness (viz. the coast-sections in Trinidad) indicate not less than 4000 feet. The same fossils seem to traverse the entire series, some of them belonging to existing species. The antiquity of the formation possibly ascends to the mid-tertiary period, as the analogies with the fauna of the Basin of Vienna, and of the Faluns, seem to refer it to the Miocene horizon. A striking contrast between the conditions prevailing in Trinidad and on the main exists in the positions of the strata, which on the continent are invariably horizontal or not exceeding 5°, whilst in Trinidad they are almost constantly highly inclined, often vertical, and exhibiting the numerous violent but partial accidents which have affected the system.

Those singular substances termed *porcellanites* by the Germans (*thermantides* of Cordier) are of common occurrence in the shaly and carboniferous portions of the series in Trinidad, and are unquestionably attributable to the natural combustion of the lignite and vegetable débris diffused so generally in this formation. The result of this process is to bake and indurate the contiguous strata for a vertical extent of sometimes 70 to 80 feet, converting them into substances widely varying from their original condition. Thus the clays present a material resembling extremely compact brick, and are brilliantly coloured by the anhydrous peroxide of iron. The shales are still fissile, but brittle and crowded with the impressions of leaves and woody fragments sharply defined, whilst the siliceous beds are usually transformed into a species of porcelain-jasper.

The asphalt of Trinidad is almost invariably disseminated in the upper group of the "Newer Parian." When *in situ*, it is confined to particular strata, which were originally shales containing a certain proportion of vegetable débris. The organic matter has undergone a special mineralization, producing bituminous, in place of the ordinary anthraciferous, substances. This operation is not attributable to heat, nor of the nature of distillation, but is due to chemical reaction at the ordinary temperature and under the normal conditions of the climate. The proofs that this is the true mode of generation of the asphalt repose not only on the partial manner in which it is distributed in the strata, but also on numerous specimens of the vegetable matter in process of transformation and with the organic structure more or less obliterated. After the removal by solution of the bituminous material, under the microscope a remarkable alteration and corrosion of the vegetable cells becomes apparent, which is not presented in any other form of the mineralization of wood*. A peculiarity attending the formation of the asphalt results

* For the details of this subject, see, in the 'Report on the Geology of Trinidad,' Appendix G, on the asphaltic deposits, and Appendix K, containing Mr. Cruger's contribution on the fossil plants.

from the assumption of a plastic condition, to which property its frequent delivery at the surface is partly referable; where the latter is hollow or basin-shaped, the bitumen accumulates, forming deposits such as the well-known Pitch-lake. Sometimes the emission is in the form of a dense oily liquid, from which the volatile elements gradually evaporate, leaving a solid residue.

Mineral pitch is also extensively diffused in the province of Maturin, on the main (the other districts of the Llanos were not sufficiently examined to determine its existence, which, however, is generally affirmed), and in still larger quantities near the Gulf of Maracaybo, on the northern shores of New Granada, and in the valley of the Magdalena, where it probably is a product of the same tertiary formation.

The phenomenon of salses or mud-volcanos, consisting of the solution of inflammable gas accompanied by the discharge of a muddy fluid and asphaltic oil, is perhaps closely related to the activity just described, as carburetted hydrogen may be disengaged in the direct formation of asphalt*. Several of them occur in Trinidad also, in the "Newer Parian." They were likewise observed in the province of Maturin, presenting similar characters. At Turbaco, near Carthagena, precisely the same action is manifested, but on a much larger scale. This is further confirmatory of a great extension of the above formation to the westward.

The thermal waters of Trincheras, near Valencia, issuing from mica-schist, contain merely traces of silica, sulphuretted hydrogen, and nitrogen, and possess a variable temperature, as shown by the following determinations:—

Humboldt, in 1800	194°
Boussingault, in 1823	206°
The author, in 1859	198°

The hot springs of Chaquaranal, near Pilar, in a limestone of the "Older Parian," are of a highly interesting nature, presenting the rare phenomenon of waters discharged at, and even over, the boiling-point. There are several centres of issue, situated in adjacent ravines. Sometimes the fluid is delivered under pressure, rising in a jet, continuing in a state of ebullition for several feet from the point of discharge, accompanied by a forcible evolution of steam, and depositing abundance of calcareous matter. The fissures of the adjacent rock are lined with spathose crystallizations, and the acicular forms of sulphur. The vapours escaping from these fissures consist principally of steam.

A species of *Souffrière*, termed the "Azufral grande," only half a mile distant, comprises several orifices, from which heated vapours, strongly impregnated with sulphuretted hydrogen, are evolved; the sides of the cavities are coated with quantities of large crystals of sulphur; and the adjacent surface, for an extent of a quarter of an acre, is covered by a variety of purely siliceous deposits, sometimes

* A detailed description of the salses of Trinidad is contained in Appendix H. of the 'Report.'

resembling sinter, often agatiform or chalcedonic. Probably a solution is occasionally discharged in which the hydrate of silica is dissolved by carbonic acid and sulphuretted hydrogen: on arriving at the surface the excess of these gases would be volatilized, and the siliceous matter precipitated in more or less hydrated forms. There was no evidence of the silica having been combined with an alkaline base, a condition under which it has often been supposed that that substance passed into solution. The surface, quite devoid of vegetation, is occupied by a sandstone, also of the "Older Parian" series; instead of the usual reddish shade, however, it is of the purest white, evidently from the bleaching action of the acid waters. The mode in which the various tints are communicated to the siliceous substances can be very distinctly traced, since the only sources of colouring matter proceed from the sulphur deposited from the water, and the carbon and mineral principles of the decaying leaves which are blown from the adjacent woods. The yellow colours are due to the sulphur, and the brown and other shades to the vegetable matter. Additional manifestations of the same nature are stated to exist in the vicinity; but the opportunity for their inspection was not afforded. These phenomena, including the thermal waters, may be due to the same chemical activity, producing different results according to the nature of the strata traversed by the vapours and fluids. The derivation of the dissolved silica may perhaps be attributed to the cementing substance of the sandstone, the more or less hydrated condition of this cement rendering it susceptible of solution in heated acidulated waters.

These suppositions also readily explain how, in two adjacent cases, the deposits should be exclusively calcareous in one, and equally siliceous in the other, thus corresponding with the mineral character of the rock in which the agencies occur.

The respective areas occupied by the three groups constituting the territory embraced within the 8th and 10th parallels, and the 61st to 69th meridians, may be approximately estimated as—

	square miles.	
Caribbean	7,600	Serranía.
Older Parian (Lower Cretaceous) .	9,900	
Newer Parian (Miocene?)	36,500	Llanos.
Total..	54,000	

Several memorable earthquakes have agitated the northern littoral of Venezuela, destroying Cumaná in 1797 and Caracas in 1812. A severe convulsion affected the former town and a large extent of the adjacent surface on the 15th August, 1853. The shock, which occurred at 2 p.m., with a duration of more than 50 seconds, is described as proceeding from north-east to south-west with a horizontal progression, and terminating by vertical oscillations. In Cumaná scarcely a house remained uninjured, and the larger buildings, such as the fort, bridge, college, and churches, were entirely demolished.

Notwithstanding the constant restoration, even in 1859 every quarter of the town was still encumbered with masses of ruin.

From the researches hitherto prosecuted in South America, it would seem that the earlier systems of the Secondary epoch, viz. the Triassic and Jurassic, are very partially represented* in the deposits of that continent. Formations referable to the Cretaceous era are, on the contrary, much more general, and seem to occupy vast spaces in New Granada†, Peru†, Chili†, Brazil†, and near the Straits of Magellan†. The organic remains from the first-mentioned region have been shown by Von Buch and D'Orbigny to correspond very closely with the Neocomian fauna of Europe, and even to offer a considerable number of identical species. According to Mr. Darwin, the same is the case with the deposits of Chili, whilst those of the Straits are referred by M. d'Orbigny to his Upper "Néocomien" or "Aptien."

It is interesting to find this period again represented in another province of the same great geographical region, since the "Older Parian" formation, described in this notice, must also be associated with the Lower Cretaceous horizon. A parallel may be suggested between the mineral nature of the series east of Barcelona and the hard dark limestones, the marls, and sandstones described as pertaining to the formation in New Granada; whilst the shaly slates of the western range seem to resemble the indurated schists observed near Port Famine, in the Straits.

Although equivalent to the older or Neocomian period of the Cretaceous epoch, yet we should vainly search in Europe for any correspondence with the vast development presented by this great formation in the northern part of the South American continent. We have seen how in North-eastern Venezuela it constitutes a great mountain-series, including summits of over 7000 feet, assuming, according to the statements of observers, in New Granada more colossal forms, and prevailing at elevations of upwards of 12,000 feet. Nor is even that, perhaps, the final limit, since there is a high probability of the "Older Parian" extending along the great arc of the eastern chain uniting Valencia and Bogotá, and, consequently, of its contributing to the structure of those still loftier heights of the province of Méridá, which attain or even surpass 14,000 feet.

These considerations may suffice to express how deep an interest must attach to an extension of our knowledge respecting the formation in question, of which the proper exploration and description are amongst the most important and attractive subjects awaiting the future investigators of South-American geology.

* Bayle et Coquand, "Fossiles du Chili," Mém. de la Société Géologique de France, t. iv.

† D'Orbigny, Voyage en Amérique, Géologie et Paléontologie, Part iii. Von Buch, Pétrifications recueillies par Humboldt. Darwin, Voyage of the 'Beagle,' Geology, Part iii. pp. 151, 180, &c. Pictet, Paléontologie, ii. p. 54.

2. *On the* Coexistence *of* Man *with certain* Extinct Quadrupeds, *proved by* Fossil Bones, *from various* Pleistocene *Deposits, bearing* Incisions *made by sharp Instruments.* By M. E. Lartet, Foreign Member of the Geological Society.

[In a Letter to the President.]

You have been good enough to offer to communicate to the Geological Society of London the observations which I have for some time past made upon fossil bones exhibiting evident impressions of human agency. The specimens of them which I showed to you yesterday were those only whose origin is authentic, and which were obtained from deposits well defined in regard to geological relations. Thus the fragments of the Aurochs exhibiting very deep incisions, apparently made by an instrument having a waved edge, and the portion of the skull of the *Megaceros Hibernicus*, in which I thought I recognized significant marks of the mutilation and flaying of a recently slain animal, were obtained from the lowest layer in the cutting of the Canal de l'Ourcq, near Paris. These very specimens are figured or mentioned by Cuvier (Oss. Fossiles, 4to. 1823, tom. iv. pl. 6. fig. 9, *M. Hibernicus*); and Alex. Brongniart (Descr. des Environs de Paris, 4to. 1822, p. 562, pl. 1 A. fig. 10) has given a detailed description of the deposit, consisting of distinct layers, which he considers to be of higher antiquity than those of the valleys. The bones of the Aurochs and the *Megaceros* were found in the same layer as the remains of the Elephant (*Elephas primigenius*) of which Cuvier has given figures of two molars, which, according to that author, had not been rolled, and were found under circumstances which showed that they were in an original and not in a *remanié* deposit. I have said that the deep incisions on the bone of an Aurochs from the cutting of the Canal de l'Ourcq (which you may remember I showed you in the Gallery of the Jardin des Plantes) appear to have been made by an instrument with a waved edge. By this I meant an instrument having an edge with slight transverse inflections, so as to produce, by cutting obliquely through the bone, a plane of section somewhat undulated. The cut seems to have been made by a hatchet not entirely finished—a state in which the greatest part of the flint implements from St. Acheul, near Amiens, seem to be; but in the marked bones of Abbeville and other ancient localities the incisions must have been made by rectilinear edges. These considerations would lead us to think that, independently of the case of the hatchets simply chipped and roughed out, the place for the manufacture of which might be near that where they are now found, those primitive people must have been provided with more perfect instruments, such as would be more suited to their ordinary wants. I should therefore hesitate to adopt the system (too absolute, in my opinion) of Mr. Worsaae, who distinguishes the first subdivision of the "Stone Period" by hatchets that are merely chipped, to the exclusion of those that are polished, which he assigns to the second subdivision. It is to be presumed that the want of instruments with polished surfaces and having a fine cutting edge must have been felt from the

earliest time, when the people had learned to fix, by a much more difficult process, to flints and other rocks intentional forms so well defined.

Among the bones with incisions obtained from the sands of Abbeville, there is a large antler of an extinct Stag, referred to the *Cervus Somonensis*, or the *grand Daim de la Somme* of Cuvier, together with several horns of our common Deer, which I was not able to show you. The bones of the *Rhinoceros* (*Rh. tichorhinus*) which I laid before you were found at Menchecourt, a suburb of Abbeville, where there are gravel-pits which formerly afforded many fossil bones of Elephants, &c., and where M. Boucher de Perthes, at a later period, obtained the flints worked by human hands. The incisions that may be observed on those bones are neither so deep, nor do they afford evidence so striking, as those in the bones of the Aurochs from the Canal de l'Ourcq; but the shallow cuts and the incisions of the bony surfaces which may be observed upon them, especially in the articulations, have in my eyes not less value; for I have satisfied myself, by comparative trials on homologous portions of existing animals, that incisions presenting such appearances could only be made in fresh bones still retaining their cartilage. As to the fragment of the horn of the *Megaceros Hibernicus*, which Cuvier had received from England without any indication as to where it came from, you may have observed that it bears the marks of several blows, which have made incisions of a depth that it would be impossible to produce in the present state of mineralization of that fragment: further, the blow which detached that piece from the rest of the horn must have been given before that immersion in the sea which caused its fossilized condition; for in the internal cavity of this fragment there was found the valve of an *Anomia* (preserved with the specimen), which could not have found its way there except at the place of fracture. I have observed very significant marks, evidently produced by a sharp tool, on the horn of a young *Megaceros* which the late M. Alcide d'Orbigny had received from Ireland some years ago.

I would call to your recollection that the Rev. John Cumming, in his geological description of the Isle of Man (Quarterly Journal of the Geological Society, vol. ii. p. 345), notices the occurrence of the remains of the *Megaceros* imbedded in blue marl "with implements of human art and industry, though of an uncouth and ancient character;" and in a note at the foot of page 344, alluding to a submarine forest, to which he is inclined to assign a more ancient date, he says, "It is singular that the trunk of an oak tree, which has been removed from the submerged forest at Strandhall, exhibits upon its surface the marks of a hatchet." With regard to the historical existence of the *Megaceros*, after referring to what is to be found in the works of Oppian, of Julius Capitolinus, and S. Münster*, I have found nothing

* For the text of Oppian I have consulted the French translation of the poem "de la Chasse" by Belin de Ballu (1787), chant second, p. 42. Julius Capitolinus is quoted by Aldrovandus, 'de Quadrupedibus bisulcis,' lib. i. c. xxviii. p. 857. Aldrovandus explains why he has changed his opinions after having received from an English physician the head of (*Megaceros*) *Euryceros*, which he has

which appears to me to justify in this respect the opinion put forth by Dr. Hibbert, and since then accepted by other palæontologists, except Professor Owen, who, speaking of the *Megaceros* of the British Isles, entirely dissents from the opinion of Dr. Hibbert. All the remains of that animal found on this side of the Channel, which I have examined, belong to deposits of greater antiquity than that of the peat-bogs.

M. Delesse has shown you fragments of bone that have been sawn, which he recently obtained from a deposit in the neighbourhood of Paris, where he had previously collected remains of the Beaver, the Ox, and the Horse. From an examination of these fragments, I have satisfied myself, by experiments on recent bones, that the action of a metallic saw would not produce the transversally striated plane of section which you must have observed on those ancient bones collected by M. Delesse; but I have obtained analogous results by employing as a saw those flint knives, or splinters with a sharp chisel-edge, found in the sands of Abbeville.

If, therefore, the presence of worked flints in the diluvial banks of the Somme, long since brought to light by M. Boucher de Perthes, and more recently confirmed by the rigorous verifications of several of your learned fellow-countrymen, have established the certainty of the existence of Man at the time when those ancient erratic deposits were formed, the traces of an *intentional operation* on the bones of the *Rhinoceros*, the *Aurochs*, the *Megaceros*, the *Cervus Somonensis*, &c., supply equally the inductive demonstration of the contemporaneity of those species with the human race.

It is true that certain of those species, the *Cervus elaphus* of Linnæus (the same as your Red-deer or Stag) and the Aurochs, are still represented in existing nature: but although it be exactly the bones of the Aurochs which exhibit the most evident proof of human action, the fact is not of less value as regards the relative antiquity; for the remains of the Aurochs have been found associated in the same beds with those of *Elephas* and *Megaceros*, not, as I have already said, by the effect of a *remaniement*, but in an original inhumation. Moreover, fossil remains of the same Aurochs have been found in England, in France, and in Italy, in præglacial deposits (that is, in deposits anterior to the most ancient pleistocene formations imbedding bones of *Elephas primigenius* and *Rhinoceros tichorhinus*). I would add, that the more rigorous observation of facts tends clearly to demonstrate that a great proportion of our living Mammifers have been contemporaneous with those two great extinct species, the first appearance of which in Western Europe must have been preceded by that of several of our still existing quadrupeds.

figured. There is another citation, and some conclusions interesting to read, at page 742 of the same work.

With regard to S. Münster, I have not taken notice of more than plate 9. fig. 2. of his 'Cosmographia Universalis.' But you will find his text reproduced and interpreted by Dr. Hibbert in the 'Edinburgh Journal of Science,' 1830, vol. ii. p. 307. Dr. Hibbert has likewise given the figures of Münster, which are evidently fantastical, as admitted by the most eminent men of science in Germany.

In endeavouring to connect those proofs of the antiquity of the human race with the geological and geographical changes which have since taken place, I have not met with any more precise induction than that offered by M. d'Archiac, viz. the relative epoch of the separation of England from the Continent. The former connexion of the two is a fact generally admitted: it is proved by the similarity in structure of the opposite sides of the Channel, by the identity of species of terrestrial animals, the original intermigration of which could only have been effected by the existence of *terra firma*. M. d'Archiac (Bull. de la Soc. Géol. de France, 1ère série, t. x. p. 220, and Histoire des Progrès, &c., t. ii. pp. 127 & 170) has been led, by a series of well-weighed inductions from stratigraphical considerations, to consider the epoch of the separation of the British Islands as occurring after the deposition of the diluvial rolled pebbles, and before that of the ancient alluvium, the Loess of the North of France, of Belgium, the Valley of the Rhine, &c. The inference to be drawn from that hypothesis is self-evident: it is this, that the primitive people to whom we attribute the hatchets and other worked flints of Amiens and Abbeville might have communicated with the existing land of England by dry land, inasmuch as the separation did not take place until after the deposit of the rolled diluvial pebbles, from among which the hatchets and worked flints have been collected. On the other hand, M. Elie de Beaumont having assigned the production of the erratic phenomena existing in our valleys to the last dislocation of the Alps, we should be authorized to conclude from this second hypothesis, that the worked flints carried along with the pebbles in that erratic deposit in the bottom of the valleys afford a proof of the existence of Man at an epoch when Central Europe had not yet reached the completion of its present great orographic relief.

While it has been held that no change has taken place in the great lines of level since the formation of the erratic deposits in the lower parts of our valleys, and although such changes cannot be distinctly traced in the central parts of the continents, from the absence of standards of comparison, they are not the less easy to be recognized as having occurred, even since the existence of Man, throughout the whole extent of the European coasts, from the Gulf of Bothnia to the very eastern extremity of the Mediterranean. They have been observed by different authors on a considerable number of points of the coast, where they have verified the existence of objects of human industry in deposits of marine origin, raised up at different elevations above the sea-level. Such changes, be they the result of action more or less violent, of movements more or less sudden, have not amounted to catastrophes so general as to affect to a sensible degree the regular succession of organized beings.

We find incontestable proof of this in the British Islands, whither the most considerable number of terrestrial species must necessarily have immigrated prior to the separation of those islands from the Continent, and where they have established themselves and have continued by successive generations to the present day. The same

thing has occurred on the Continent, where the same terrestrial fauna has continued without any other modifications than the geographical displacement of certain species and the final disappearance of some others—disappearances that have resulted, not from a simultaneous destruction, but rather from a series of successive extinctions which appear to have been equally gradual as regards space and time.

I may add to what I have stated above, that the finding of worked flints in the diluvium of Amiens and Abbeville is by no means an isolated fact. M. Gosse of Geneva, a young medical student in Paris, has recently discovered in the sands of the Parisian suburb of Grenelle, of the same age as those of Abbeville and of other parts of Europe, a flint hatchet of a most distinct form, together with knives or thin plates split in a longitudinal direction. I myself have had an opportunity of verifying these facts in the collection formed by that skilful explorer. He has shown me an Elephant's tooth, a canine tooth of a large Feline animal, and bones of the Aurochs, Horse, &c., all obtained from the same sands and from the same bed in which the flint hatchet was found.

I may add that, among the bones obtained in Switzerland under the lacustrine habitations of the Stone Period (in the lakes of Moosdorf, Bienne, and others), there never have been found any remains of the *Megaceros*, although the remains of the Elk, the Aurochs, and the *Bos primigenius* are by no means rare. In Denmark, where still more ancient stations have been carefully examined with the same object, Prof. Steenstrup has assured me that he has never discovered the smallest fragment of the *Megaceros* in the midst of the most abundant remains of the Reindeer, Elk, Aurochs, and other species of animals which from time immemorial have not existed in that region. Nevertheless these primitive stations in Denmark are referred back to a period when no other domestic animal existed in that country except the Dog. No remains have been found either of the Horse, Sheep, or Goat,—not even any kind of dwarf Ox.

If, Sir, you are of opinion that the above notes, drawn up in haste, are likely to prove interesting to the Geological Society of London, I should be happy if you would submit them to the enlightened judgment of your learned associates, and if they will receive them at the same time as a mark of my deference, and as a feeble expression of the profound gratitude I feel for the honour conferred upon me by my name having been inscribed among the Foreign Members of that Society.

Addition by the PRESIDENT.

In the foregoing communication, M. Lartet has referred to my friend M. Delesse having shown me some fragments of bone bearing incisions made by a sharp instrument, which he had recently discovered in the neighbourhood of Paris. He presented me with one of those which he had submitted to the examination of M. Lartet, and which I now lay before the Society, together with the following copy of a note I received from M. Delesse describing this specimen :—

"I send you a fragment of a rib which I recently found at Ver, in the department of the Seine et Oise, about nine leagues from Paris, at the depth of three mètres (nearly ten feet), in a kind of cleft filled by the diluvial soil (*le terrain diluvien*), occurring with the sandstone and sands belonging to the *étage* denominated *les sables de Beauchamp*. It was associated with divers bones of the Stag and Horse, and also of an animal no longer existing in the country, namely, the Beaver. I have submitted this fragment to M. Lartet, with whose profound scientific attainments you are well acquainted; but he has not been able to decide whether it belongs to a species of quadruped still living, or to one now extinct. But he considers this small fragment of a rib very interesting, from its having at one extremity traces of a rude operation of sawing, and presenting an appearance very different from that which would be produced by a metallic blade or by a saw. M. Lartet did not rest satisfied with a mere conjecture, but ascertained by experiments on a fresh rib of an Ox that a metallic blade produced a uniform and almost a smooth cut. Hence he concludes that the rib in question had been sawn by a flint with a jagged edge. Taking a splinter of flint with a chisel-edge from the sands of Abbeville, he easily sawed a fresh rib, but always obtained an uneven, irregular cut (*des surfaces de resection avec reprises nombreuses*), such as may be observed on the specimen I send you. There is therefore every reason to believe that this rib had been sawn by a flint, and it affords proof of Man having lived in France at the same time as the Beaver, an animal no longer existing with us; and M. Lartet has thus supplied a new and elegant demonstration of the contemporaneity of Man and quadrupeds during the period of the *Terrains diluviens*." L. H.

Subsequent addition by the President.

The day after the above communication was read, on showing the fragment of bone given to me by M. Delesse above referred to, it was observed that it had a remarkably fresh appearance, that it did not adhere (*happer*) to the tongue as fossil bones usually do, and that thus a doubt might exist as to its assumed antiquity. After hearing this remark, I exposed a minute fragment to the flame of a candle, when it gave out the odour of burnt animal matter; and on immersing another fragment in hydrochloric acid, after effervescence, a soft gelatinous substance, nearly the size of the original fragment, was left. Knowing full well that M. Delesse and M. Lartet would cordially agree on the importance of the most scrupulous investigation of every fact produced in evidence on this recently-agitated question of the antiquity of Man, I communicated to both of them what I have stated above respecting this bone. I received immediately answers from them; and these, with their leave, I now give, not only because of their confirmation of the opinions they formerly expressed, but as containing some additional remarks of much interest.

M. Delesse, in his letter dated the 19th instant, says:—

"The specimen of the rib which I gave you was incontestably found in a sand-pit (*sablonière*), where it was associated with the bones of animals no longer existing in the country—as, for example, the Beaver. I would observe that the presence of gelatine can in no way be opposed to the antiquity of that rib. I have only just now brought to a conclusion a long series of researches by which I have shown that bones even of a high antiquity still retain a notable proportion of organic matter. If you take the bones of an *Ichthyosaurus* from the Lias, or of reptiles from the Muschelkalk, you will easily satisfy yourself that, in spite of their great antiquity, they still contain a very notable proportion of organic matter. Coprolites from the oldest formations contain it. On the other hand, bones comparatively recent, such, for instance, as those found in caverns or in travelled materials, have no great amount of organic matter. In brief, the preservation of organic matter in bones is very irregular; it depends on the nature of the rock in which they are found at least quite as much as on their antiquity.

"I pronounce no opinion as to the nature of the instrument that had been employed in sawing that rib, for I made no experiments on the subject; but M. Lartet, whose caution and sagacity are known to you, made a special examination of the question along with eminent physiologists; and they had no doubt that the rib had been cut by a sharp flint." A. D.

M. Lartet, in his letter dated the 22nd instant, states as follows:—

"I am sorry to learn that a somewhat hasty objection has been made to the palæontological value of the fragment of bone which you exhibited. I have no right to give any opinion regarding the locality where it was found, because I have not visited it; but the opinion of M. Delesse, who had an opportunity of examining all its geological features, is deserving of all confidence. Among the other fossil remains which he found in that locality, there is a fragment of bone of a Horse, having also traces of human agency, and which is in a much more altered condition than that of the bone he gave you; but there is another fragment, also bearing the mark of a saw, the appearance of which is quite as fresh as the specimen in your possession; nevertheless, when we endeavoured to authenticate this fragment specifically, we were unable to do so by comparing it with the homologous part in the skeleton of our living animals.

"It is moreover important to remark that, in any given locality, all the bones collected do not present the same degree of organic change. That depends, first, on their anatomical structure being more or less compact according to the species, and again, chiefly on the composition and physical condition of the mineral matter in which they have been in immediate and prolonged contact. Mr. Hart, in his description of the *Megaceros Hibernicus* (Dublin, 1830), states that a fragment of a rib analysed by Dr. Stokes yielded 42·87 per cent. of animal matter; and Dr. Apjohn, who analysed another

portion of a rib, states as follows:—'The bone was subjected for two days to the action of dilute muriatic acid; and when examined at the end of this period, it had become as flexible as a recent bone submitted to the action of the same solvent. The cartilage and gelatine had not been perceptibly altered by time.' It is long since the observation was made by many other persons, and especially by Schmerling (Recherches sur les ossements des cavernes de la province de Liége, 4to. 1833, 1ère par. pp. 18–52); and the remarkable researches on this subject recently made by M. Delesse, and which he is about to publish, have demonstrated that the organic change in bones by no means bears a relation to their palæontological antiquity. For example, he has found that the teeth of the bone-bed in the Upper Keuper at Oberbronn contain more azotized organic matter than most of the tusks of the Mastodon and Elephant found in tertiary or diluvial deposits. The amount of azote which they yield is even almost double that in the tusks of the Mastodon in the Miocene limestone of Sansan or in the Miocene deposits of the Upper Garonne. Thus it is evident that, if the amount of organic matter generally diminishes in proportion as the age increases, there are, nevertheless, exceptions to that general rule.

"As to external appearance, that depends also on the circumstances of the locality. It is not long since a large number of bones of the *Hyæna spelæa* were sent to me, which had been obtained from an ancient alluvial deposit in the centre of France. They were in no degree changed in weight or colour, and in external appearance they were quite as fresh, if not more so than the fragment given to you by M. Delesse. I have some of them now in my possession; and they are still so much impregnated with animal matter, that I was able with the utmost ease to saw and cut them with a flint knife. On the other hand, I have now before me a statuette made of stag's horn, obtained from a grave at the external base of a barrow, certainly not older than the 12th century, the substance of which is so much altered that it might be said to be fossilized, in a certain sense of the term, as much as the greater part of those found in caverns or diluvium. Hence we perceive that the greater or less amount of alteration in bones is not a character from which we can absolutely determine their palæontological antiquity.

"With regard to the mode by which the fossil bones of M. Delesse have been sawn, I must confess that at first sight I thought, as M. Desnoyers did, that the operation must have been performed with a metallic plate; but upon a more attentive examination of recent bones, I became convinced that the peculiar appearance presented by the section of one of the bones in the possession of M. Delesse must have been produced by the employment of a sharp tool of *flint*, rather than by a metallic plate, which has always given me a section with a very different surface. I send you the extremity of a tooth of *Hyæna spelæa*, which has been sawn by a flint. If you examine with a magnifying glass the plane of the section, you will find the same system of *striæ* as are observed in the bones collected by M. Delesse,

sawn with the same kind of tool. You may further satisfy yourself that in this fragment nearly all the organic matter remains, although the tooth comes from ancient deposit."

In my letter to M. Lartet I had said that when his communication was read, Dr. Falconer observed that, a considerable time ago, M. Marcel de Serres had given an account of a fossil Stag's horn that had evidently been cut. On this M. Lartet observes—"It is very true, as Dr. Falconer remarked, that M. Marcel de Serres gave a figure in 1839 of a Stag's horn cut and fashioned by human hands. I had occasion to remark that, a long time before, M. Tournal in 1829 (Ann. des Sc. Nat. 1829, t. xviii. pp. 242 *et seq.*) and Schmerling in 1833 (*loc. cit.*) had made similar observations. I might myself have stated that among the bones of caverns I had seen those of the Rhinoceros and the Reindeer bearing marks that must have been made by man; but I was on my guard against bringing forward those facts, because they would only have afforded opponents an opportunity of bringing forward anew their favourite objection, viz. 'that nothing that had been observed in caverns was deserving of any confidence, and that the traces left by man on fossil bones might have been made a long time after the introduction of the bones into the caverns.'

"What constitutes the whole value of my observations on the impressions or marks of human agency on the fossil bones found in the diluvial deposits of Abbeville, and in the cutting of the Canal de l'Ourcq, is this, that, once admitting the reality of those marks, their relative antiquity becomes rigorously demonstrated by the geological circumstances of their locality being clearly defined. At Abbeville the marked bones, as well as the flint hatchets, were found in the diluvial gravel, which is itself covered by the Loess deposit. In the cutting of the Canal de l'Ourcq, the bones of the *Aurochs* and those of the *Megaceros Hibernicus* were found at a depth of 7 mètres (23 feet), in a bed of earth (*limon*) and under other beds in normal stratification. They were not rolled (as Cuvier has said), and were mixed with the remains of an Elephant, and evidently under the conditions of an original deposit.

"At the meeting of the Geological Society of France yesterday evening, M. de Verneuil exhibited a worked flint hatchet and an Elephant's tusk found in the gravel-pit of Précy, near Creil, in the valley of the Oise. Thus these worked flints have been found in the diluvium of three of our valleys—of the Somme, the Seine, and the Oise."—E. L. (L. HORNER, May 31, 1860.)

May 30, 1860.

Mark Fryar, Esq., Lecturer on Mining, &c., at the Andersonian University, Glasgow, and Francis Duncan, Esq., Lieut. R.A., Halifax, were elected Fellows. Dr. Henry Milne-Edwards, Professor of Zoology &c., Jardin des Plantes, Paris, was elected a Foreign Member.

The following communications were read:—

1. *On certain* Rocks *of* Miocene Age *in* Tuscany, *including* Serpentine, Copper-ores, Lignite, *and* pure Alabaster, *used in Sculpture.* By W. P. Jervis, Esq., F.G.S.

[Abstract.]

The geology of Tuscany is peculiarly interesting, though presenting many difficulties to the palæontologist and field-geologist, owing to the diversified changes which have been produced on the sedimentary strata since their consolidation.

These metamorphic agencies are still at work in Central and Southern Italy, either in the form of simple hot vapour-emanations, or the more extended and allied volcanos whence solid matter is also ejected. On the other hand, no such phenomena are seen N. of the Arno, where nature has been comparatively quiescent since the close of the Miocene period.

Most of the metamorphoses of the Italian rocks appear to be of comparatively recent origin; nor can I find any proof of their existence at all previous to the close of the Mesozoic period or the beginning of the Eocene. Serpentinous rocks then first upheaved the littoral of Piedmont and Tuscany, where they formed the eastern barrier of the Maremme,—probably producing an archipelago of little islands surrounded by an iron-bound coast, many of them rising to the height of several hundred feet, covered by a peculiar flora in certain portions where soil was formed by the disintegration of the magnesian rocks. Four consecutive and allied eruptions are distinguished by Italian geologists. Three are considered as having occurred during Tertiary times; the fourth, during the Mesozoic epoch, is the oldest, and must be first spoken of.

The geography of the Serpentine-eruptions has been described by Savi, who enumerates four series, lying more or less parallel to the chain of the Apennines. Throughout the whole of Italy, the lithological appearance of each successive eruption is so typical that it may be easily borne in mind, arising from the fact that the elements of which they are composed have a widely different chemical constitution—probably due to the then molten matter having been ejected from different depths, perhaps even from different foci. In order to describe the Miocene eruptive rocks, we must first refer to the pre-existing eruptions to which I have just alluded; otherwise the phenomena which present themselves will not be so well understood.

I. *Diallagic Serpentine.*—Never enclosing fragments of Tertiary

rocks; piercing the Upper Cretaceous beds; prevailing colour deep olive- or leek-green, with metallic-looking grey or blackish crystals of bronzite, generally not exceeding a quarter of an inch in length; extremely compact and difficult to cut; susceptible of a fine polish (whence its employment in architecture); never accompanied by ores.

II. *Euphotide* or *Granitone.*—Typical form a very dense rock, with large crystals of diallage and milk-white or slightly steel-grey crystals of felspar of the hardest kind. The latter are replaced in some localities wholly or in part by steatite—as at Impruneta, where the diallage is easily cleaved by the nail: this is fawn-coloured, and when in large crystals, from its softness, renders the rock unfit for building-purposes, the constituent parts having very unequal hardness. In contact with the diallagic serpentine it produces a metamorphism of that rock, originating the "Ranocchiaja." The latter is only found within a few yards of the contact of the two eruptive rocks, and is therefore difficult to procure in considerable quantities. It is streaked over with green and yellow markings, which anastomose like capillary blood-vessels. The margin of the euphotide in contact with the serpentine is often even and smooth, as if friction had taken place: frequently a space of an inch or two may be seen between the surfaces, evidently produced during the act of cooling.

Near Matarana (Liguria), within a few yards of the serpentine the euphotide contains crystals of diallage half an inch in length, their size diminishing to a quarter of an inch at the junction with the older rock—whence also it is proved to be the newer of the two. In receding in the contrary direction, the crystals of diallage are perfectly developed, and $1\frac{1}{2}$ inch long.

III. *Diorite* (*Greenstone*).—Penetrating the former; like it, of Eocene origin; may be seen in the neighbourhood of Miemmo, at the bottom of the copper-mine of Monte Catini, &c.

The diorite and serpentine acting on the Eocene "macigno," a micaceous sandstone, has produced the "gabbro rosso," a brick-red schistose rock, in which the ancient stratification is sometimes clearly visible, though the rock is often broken up into fragments, rendering it very difficult to obtain specimens a foot long without flaws. The strata are extremely contorted, and in some places have evidently been so altered by igneous action in contact with neighbouring rocks as to have the appearance of having been themselves erupted.

IV. *Serpentine without Diallage* (locally termed "gabbro verde"). —This rock is at once distinguished from the older serpentine, as it never contains diallage—silicate of magnesia preponderating. White steatite is frequently found in it in such large quantities as to impart a soapy feel: the absence of bronzite causes it to be wanting in the hardness and strength of the older serpentine.

Being the first of a series of phenomena of the Miocene period, I will describe it more fully. This "gabbro" is sufficiently soft to be quarried with a pickaxe, while the diallagic serpentine requires to be blasted with gunpowder. Exposed to the great vicissitudes of Italian climate, the gabbro becomes very friable, the surface readily crumbles, and it weathers to a considerable depth: a kind of steatitic

clay is produced by its disintegration. The colour varies in different places, though in general consisting of yellow and green, imperfectly mixed. The colouring matter is oxide of iron or manganese; in some cases, as much as 2 per cent. of oxide of chromium.

The surface of the rock has frequently a polished greasy appearance, though the form is not so regular as our "slickensides," which are perfectly flat. Here the margin does not present any planes, but has followed the sinuosities of the rock against which friction has taken place. Its structure is so incoherent that a blow with a hammer shatters a mass into small fragments; though in subterranean galleries much pervaded with water it appears to acquire much tenacity. Gabbro seems to me to be in many places a decomposing rock.

The topographical appearance of the serpentine-eruptions is very characteristic: there is an entire absence of those undulating chains or eminences, melting insensibly into one another, which enable us to classify hills into groups. These rocks form dykes, but more generally constitute whole hills of conical form, rising abruptly to a considerable height, and terminating in rugged, sharp summits. The older rocks have been much upturned and elevated, and are thrown off in every direction,—the serpentine, forming the nucleus of the mountains so abundant along the west coast of Tuscany, Modena, and Piedmont, generally reaching the surface somewhere near the centre, forming (if I may be permitted the expression) a "periclinal" axis.

The older rocks, nearer the focus of action, are the most disturbed. No feature regarding this serpentine is more important than that of its being almost invariably accompanied by rich ores of copper at its junction with the metamorphosed schists or gabbro rosso. These two rocks, similar in name, are entirely distinct in most other respects: one is an aqueous, the other an igneous rock.

Many minerals are peculiar to the junction of the gabbro rosso and the Miocene serpentine; they are chiefly zeolites. The commonest is caporcianite, a white crystalline mineral, tinged with pink, in structure resembling analcime. These zeolites *all contain magnesia*. They are,—

	Magnesia per cent.		Magnesia per cent.
Savite, containing	13·50	Portite	4·87
Schneiderite	11·03	Sloanite	2·67
Picranalcime	10·25	Humboldtite	2·12
Picrotomsonite	6·27	Caporcianite	1·11

Miemmite (dolomite) contains 42·5 per cent. of magnesia; "gabbro," from La Spezia, 24·4.

Calcareous spar also occurs in limpid and extremely obtuse rhombohedral crystals; it probably owes its origin to the metamorphosis of the limestones. I consider all these minerals to have been produced at the period of the intrusion of the Miocene serpentine, from whence they doubtless derived their magnesia. It is also interesting

to find that large quantities of the limestone in the neighbourhood have been altered into dolomites,—the miemmite, a delicate greenish rock of the same colour as aquamarine, being a double carbonate of lime and magnesia.

The copper from the serpentine is not associated with galena and blende as with us, but is accompanied by many asbestiform minerals.

The action of the serpentines on the limestones which they have traversed is very varied. Near Matarana I noticed the action on a mouse-coloured limestone, where peroxide of iron had imparted a brick-red tinge to various parts of the mass. Within a yard or two of the serpentine the rock had been apparently broken into fragments, which had been cemented by delicate veins of serpentine flowing into and filling up the cracks. This beautiful metamorphic rock, called "Oficalce," is, in fact, calcareous serpentine: it forms a rich combination of colours—deep red and dark green, with interlacing veins of pure-white calcareous spar. I would offer this explanation: total decomposition of the limestone was prevented by the pressure; the carbonic acid was partially expelled; the heat decomposed the carbonate of iron which was present in minute quantities, and completely peroxidized its protoxide of iron, which, being no longer isomorphous with the pure carbonate of lime, was rejected as the latter crystallized out in various parts. If I am not mistaken, this would prove that the crystallization of carbonate of lime in prisms (as arragonite) only takes place within *limited degrees of temperature*, *above* and *below which* the crystalline system is the *Hexagonal*.

The copper-mine of Monte Catini is found at the junction of the gabbro rosso and the Miocene serpentine; the ore is invariably in the latter. It is one of the finest to be seen anywhere, and dates at least from the Florentine republic: Cosmo I. reopened it in 1562; but it was not regularly worked, and, from want of experience, little was done until 1837. The indications appear to have been very favourable at the outset; but the successive proprietors failed to realize their desires, until the present company sunk to a depth of 400 feet, following the indications of ore or "vein" lying E. and W., dipping at an angle of 45° S.; they then found an immense mass of copper-ore, from whence they extracted 330 tons: about 100 feet lower a second deposit has lately been reached, the breadth of which I should estimate at 60 feet. The various ores of copper are met with in rounded masses, enveloped in serpentine; these nodules constitute a species of conglomerate,—some of the masses being ore, others boulders of serpentine, dispersed through a matrix of steatitic clay. The nodules on being broken open are found to contain chalcopyrites, or bornite, more rarely oxide of copper, grey copper, and native copper. In physical appearance the chalcopyrites differs entirely from that obtained from our mines: thus it is not lamellar or crystallized, but hard, compact, and massive, and has precisely the same structure as bornite, into which it insensibly passes in the same nodules. This pyrites is not mixed up with gangue, but perfectly pure, which can be accounted for by the expulsion of impurities, favoured, as it must have been, by the nodular condition of the

masses. The friction has produced a considerable quantity of fragmentary pyrites of the size of gravel, which is all washed and employed. I believe I am correct in asserting that iron-pyrites is nowhere found with the serpentine, even along with the ores of copper. One of the greatest advantages in working these mines is the softness of the steatitic rock. Other mines are established at Libbiano, Monte Castelli, &c.: they are newer, and have been hitherto less fortunate. Most probably, as Prof. Pilla observed, the deposits whence the rich outlying indications proceeded will be met with further down.

Closely associated with the serpentine, chalcedony is found in large quantities north of Monte Verdi; it occurs in regular veins, of considerable size. The mineral is found in blocks smooth at the surface and mammillated internally—often cavernous. I saw some remarkable masses, several feet long, in which small pieces had been cemented together by a fresh development of chalcedony, resulting in a compact siliceous conglomerate without any flaw. The pebbles were principally buff-coloured or green, the cement colourless. The neighbourhood affords specimens showing every gradation between opaque black flint, jasper, agate, chalcedony, and waxy opal.

Alabaster.—Pure-white alabaster is, I believe, peculiar to Western Tuscany, where it occurs in the Val di Marmolajo, twenty-five miles from Volterra, and eighteen from Leghorn. It is found in smooth ovoidal masses, sometimes attaining three feet in diameter.

The general section is:—

1. 6 feet light-blue bituminous marl.
2. 6 ,, greyish marls with selenite.
3. 6 ,, bituminous marls.
4. 5 to 10 ,, marls and clays containing masses of alabaster, irregularly disseminated.
5. 6 to 10 ,, marls and clays, and gypsum-beds with bituminous odour. Beds like No. 1.

6–10. Alternations of strata like the above; three of them containing alabaster.

Pure alabaster is not found in direct contact with the surrounding strata, but enclosed in an envelope of ochrey-yellow selenitic marl, at least an inch thick, firmly adhering to the surface; it is worked by pits, entrance being effected laterally, or by wide shafts. The distance between the lumps is frequently many yards; four or five rows occur irregularly disseminated. None but the pure white is extracted in the Val di Marmolajo. In the numerous interstices or fissures between the marly strata, often an inch or two wide, are found splendid limpid crystals of selenite attaining nine inches in length.

Pure alabaster is confined to the Miocene in Tuscany; but the coloured varieties extend into the Pliocene beds, and are even being produced at the present day. The heat to which the alabaster-beds have been subjected was very inferior to that of the soffioni, whence boracic acid emanates, as I have elsewhere pointed out*, and where

* See Journal of Soc. of Arts, May 23, 1860, and several successive papers in the same periodical.

anhydrite is occasionally produced. Gypsum is widely distributed where serpentine is found to pierce limestones. I chiefly noticed it at Matarana and Jano.

Lignite.—The Italian peninsula presents no "Carboniferous" coal, with the exception of isolated plants converted into anthracite, as at Jano; Miocene lignites, on the other hand, are abundant. Their area is limited, the beds being often much upturned. At Sarzanello, Piedmont, they lie at an angle of 65°: the first bed is 7 inches thick; then follows 6 feet of highly bituminous schists, which undergo spontaneous combustion on exposure to the air; lastly $6\frac{1}{2}$ feet of anthracite-looking coal, employed by the Sardinian steam-navy.

I made the following section of the pit of Castiani in the Maremme:—

54·00	metres of	clay.
3·30	,,	lignite.
9·00	,,	clay.
1·00	,,	good lignite.

Fossil fish-remains and leaves of exogenous trees are found in the shales accompanying the lignite.

The famous colliery of Monte Bamboli is the most extensive in Tuscany. A section gave the following:—

	Pit No. 1. feet.	Pit No. 2. feet.
Conglomerate .... Calcareous blue clay.... Limestone............	220	113

	ft.	in.
1st bed of Lignite	4	2
Limestone containing *Mytilus Brardi*	3	4
2nd bed of Lignite	2	0

under which comes Alberese breccia.

Besides leaves of exogenous plants, I procured remains of *Anthracotherium*; more rarely the carapaces of Tortoises have been found in the shales. It would be out of place here to speak of the economic advantages of using this lignite; however, it is so thoroughly mineralized as to resemble our Newcastle bituminous coal, and, as such, has been used in several steam-vessels, and in the arsenal at Genoa, as well as for the manufacture of rails and gas: it is said to produce excellent coke.

In conclusion, the following is a list of the principal minerals found in the Tuscan Miocene rocks:—

In the Marls.

1. Alabaster; Gypsum; Selenite.

In veins with Serpentine.

2. Jasper; Siliceous breccia; Chalcedony.
3. Opal.

In Serpentine.

4. Serpentine rock, common and noble (never contains diallage); Metaxite; Picrolite.
5. Asbestos; Amianthus; "Mountain-wood."
6. Calc-spar, in places converted into Miemmite (Dolomite)— $(CaO.MgO)CO^2$.
7. Quartz.

8. Native copper	Cu.	
9. Red oxide of copper	Cu^2O.	
10. Grey copper	$Fe^4\,Cu^{16}\,Sb^6\,S^{21}$.	
11. Bornite	$FeS+2Cu^2S$.	
12. Chalcopyrites	$FeS+CuS$.	
13. Chrysocolla	$CuO.2SiO^3+HO$	only superficially.
14. Malachite	$2CuO.CO^2+HO$	
15. Azurite	$3CuO.2CO^2+HO$	

In "Gabbro rosso;" apparently metamorphosed minerals.

16. Caporcianite—
$$3(MgO.CaO)2SiO^3+3Al^2O^3.2SiO^3+9HO.$$
17. Savite—
$$3(MgO.NaO)2SiO^3+Al^2O^3.SiO^3+2HO.$$
18. Schneiderite—
$$3(MgO.CaO)2SiO^3+3Al^2O^3.2SiO^3+3HO.$$
19. Picranalcime—
$$3MgO.2SiO^3+3Al^2O^3.2SiO^3+6HO.$$
20. Sloanite—
$$3(CaO.MgO)2SiO^3+5Al^2O^3.SiO^3+9HO.$$
21. Picrotomsonite—
$$2[3(MgO.CaO)SiO^3]+5Al^2O^3.SiO^3+9HO.$$
22. Portite—
$$3(CaO.MgO)2SiO^3+4(Al^2O^3.2SiO^3)+7HO.$$
23. Humboldtite (Datholite)—
$$2(3CaO.4SiO^3+3CaO.BO^3)+4MgO+2HO.$$

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2. *On the* OSSIFEROUS CAVES *of the* PENINSULA *of* GOWER, *in* GLAMORGANSHIRE, SOUTH WALES. By H. FALCONER, M.D., F.R.S., F.G.S. *With an* APPENDIX, *on a* RAISED BEACH *in* MEWSLADE BAY, *and the* OCCURRENCE *of the* BOULDER-CLAY *on* CEFN-Y-BRYN; by J. PRESTWICH, Esq., F.R.S., TREAS. G. S.

[The reading of this paper was commenced.]

June 13, 1860.

SPECIAL GENERAL MEETING.

It was resolved that the future Meetings of the Society shall be held in the Hall of Burlington House.

ORDINARY GENERAL MEETING.

George Angus, Esq., 3 Harcourt Buildings, Inner Temple; Herbert T. James, Esq., Drumkeeran, Co. Leitrim; and Henry Ward, Esq., Oaklands, Wolverhampton, were elected Fellows.

The following communications were read:—

1. *On the* Ossiferous Caves *of the* Peninsula *of* Gower, *in* Glamorganshire, South Wales. By H. Falconer, M.D., F.R.S., F.G.S. *With an* Appendix, *on a* Raised Beach *in* Mewslade Bay, *and the* Occurrence *of the* Boulder-clay *on* Cefn-y-bryn; by J. Prestwich, Esq., F.R.S., Treas. G.S.

[The reading of this paper, begun at the last Meeting, was concluded.]

[*The publication of this paper is unavoidably postponed.*]

[Abstract.]

The object of this communication was to give a summary of researches made during the last three years by the author and Lieut.-Col. E. R. Wood, F.G.S., the latter of whom has carefully explored at his own charge, since 1848, some of the caves previously known, as well as several discovered by himself. The known bone-caves of Gower (of which Paviland, Spritsail Tor, and Bacon Hole have already supplied Dr. Buckland and others to some extent with materials for the history of the Cave-period) are in the Carboniferous Limestone; and, with the exception of that of Spritsail Tor, which is on the west coast of the peninsula, they all occur between the Mumbles and the Worm's Head. The most important are "Bacon Hole," "Minchin Hole," "Bosco's Den," "Bowen's Parlour," "Crow Hole," "Raven's Cliff Cavern," and lastly the well-known "Paviland Caves." Bone-caves at the Mumbles, in Caswell Bay, and in Oxwich Bay formerly existed; but the sea has destroyed them. One cavern named "Ram Tor" between Caswell Bay and the Mumbles, presumed to be ossiferous, remains unexplored.

Before proceeding to describe the bone-caves and their contents, the author briefly noticed a raised beach and talus of breccia, which Mr. Prestwich had lately traced for a mile along Mewslade Bay, westward of Paviland; and he pointed out their important relationship to the marine sands and overlying limestone-breccia found in several of the Gower Caves. Dr. Falconer also referred to Mr. Prestwich's recent discovery of some patches of Boulder-clay on the highland of Gower, and in Rhos Sili Bay.

"Bacon Hole" was first treated of. It has been worked out by Colonel Wood, and described by Mr. Starling Benson. On the limestone-floor of the cave are—(1) a few inches of marine sand, abounding with *Litorina rudis, L. litoralis,* and *Clausilia nigricans,* with bones of an *Arvicola* and Birds; (2) a thin layer of stalagmite; (3) 2 feet or less of blackish sand, containing a mass of bones of *Elephas antiquus,* with remains of *Meles taxus* and *Putorius* (*vulgaris*?); (4) 1 to 2 feet of ochreous cave-earth, limestone-breccia, and sandy layers, with remains of *Elephas antiquus, Rhinoceros hemitœchus, Hyæna, Canis Lupus, Ursus spelæus, Bos,* and *Cervus*; (5) irregular stalagmite, partly enveloping a huge tusk of an Elephant imbedded below it; (6) limestone-breccia and stalagmite, from 1 to 2 feet thick, with bones of *Ursus* and *Bos*; (7) irregular bed of stalagmite, 1 foot or more, with *Ursus*; (8) dark-coloured superficial earth, kept soppy by abundant drip, with bones of *Bos, Cervus, Canis Vulpes,* horns of Reindeer and Roebuck, together with shells of *Patella, Mytilus, Purpura, Litorina* (probably brought into the cavern as food by birds), and also pieces of ancient British pottery. The marine sand at the bottom of "Bacon Hole" was analogous to that on the rocky floor of the San Ciro Cave, near Palermo, but contained fewer species of Mollusca. The uppermost layer of stalagmite is about 30 feet above high-water. The Elephant-remains belonged to at least three individuals, one of which was adult, and one young with milk-dentition.

"Minchin Hole" is the grandest and most spacious of all the Gower Caves, being 170 feet long, by 70 feet where widest, and 35 feet high at the entrance; here the section gave—(1) loose limestone-breccia, 3 feet; (2) yellow cave-earth, 9 inches; (3) sand, 1 foot; (4) blackish sandy loam containing abundant remains of *Rhinoceros, Elephas,* and *Bos,* $2\frac{1}{2}$ feet; (5) greyish-yellow marine sand, varying in thickness from 1 to 4 feet, and resting on the rocky floor. Some of the lower jaws of *Rhinoceros* from this deposit exhibit *Litorinæ* and comminuted shells imbedded in the incrusting matrix; and the black sand yielded *Helix hispida* similarly attached. In the interior, the cave-earth was thicker, and the black sandy loam more unctuous. The mammalian remains were closely analogous with those from Bacon Hole; but the Elephant-remains (*E. antiquus*) were fewer, and those of *Rhinoceros hemitœchus* were more numerous and better preserved, including two skulls. No remains of *Elephas primigenius* or of *Rhinoceros tichorhinus* were met with in Bacon Hole or Minchin Hole.

"Bosco's Den" is a cavernous fissure, of great interest, between "Bacon Hole" and "Minchin Hole." It is about 70 feet high, and has been worked out by Colonel Wood, who, having succeeded in reaching a hole called (by the quarrymen) "Bacon's Eye," found it to be an angular opening ($2\frac{1}{2}$ feet in diameter) at the top of one of the great vertical fissures in the limestone, and leading into a fine cavern. Beneath it the fissure was filled up with a mass of angular fragments of limestone (with bones, teeth, and land-shells) impacted in ochreous loam, about 20 feet in height, resting on a solid platform of breccia,

beneath which the fissure had to a great extent been washed out by the sea. On enlarging the aperture, by undermining the projecting mass of loam and breccia, a cavity was found extending 76 feet backwards, with a width of from 7 to 16 feet, and a general height of about 15 feet. A line of fissure runs along the angle of the roof, and towards the outer part of the cavern the crack widens into an irregular flue, which had evidently communicated with the surface: here the cavern rises to a height of 40 feet. When first opened, the eastern wall only of the cavern was found to be coated with stalagmite. The floor was tolerably smooth, and shelved down gradually from the mouth to the extremity, the deposits being thicker outwards. The floor having been excavated down to the hard breccia, there were observed:—(1) at the top, a bed of sandy peat or turf, formed chiefly of bits of sticks and comminuted vegetable matter, about 1 foot thick, except under the flue, where it formed a low conical heap. In or on this peaty covering were bones of Ox and Wolf, and bones and broken shed antlers of Deer, of species or varieties allied to the Reindeer (*Cervus Guettardi* and *Cerv. priscus*). (2) Stalagmite, regular, but usually less than a foot thick. At one spot it rose into a boss 2 ft. 3 in. high, which was found in a shattered condition, the fragments being loose, but still in place. This must indicate,—1st, the operation of some shock since the formation of the stalagmite, and even since the peat began to be formed; and 2ndly, the absence of drip in the cave since the shock took place. (3) Sandy loam, 1 ft. 4 in., with fragments of rock and without bones; (4) sand, 2 ft. 6 in.; (5) a bed of loose stony breccia, 4 feet, without bones; (6) ochreous loam, or the usual cave-earth, 6 to 7 feet thick, resting on the solid cemented breccia, which forms a floor or diaphragm between the upper and lower chambers of the fissure. *Ursus spelæus, Canis Lupus, C. Vulpes, Bos, Cervus*, and *Arvicola* occur in the loam, the latter in abundance. The most remarkable circumstance about these remains was the great excess of Deers' antlers above the others. Upwards of one thousand antlers, mostly shed and of young animals belonging chiefly to *Cervus Guettardi*, were collected. The lower chamber was penetrated by Colonel Wood, Dr. Falconer, and a friend, last September, and found to be washed out by the sea to a depth inwards of 31 feet; and at its extremity they met with a compact mass of marine sand and gravel, about 9 feet thick. The solid breccia forming the roof of the lower, and the base of the upper cave, increases in thickness from 6 feet at the outside to a greater depth inwards. Its materials correspond with the bed of angular *débris* observed by Mr. Prestwich on the raised beach of Mewslade Bay.

"Bowen's Parlour," or "Devil's Hole," is also a cavernous fissure in the limestone cliff, situated between Bosco's Den and Crow Hole. It has been washed out by the sea,—portions only of its cave-deposits remaining, especially a diaphragm of cemented breccia, which divides the fissure into an upper and lower storey, the former about 20 feet high at the mouth, the latter 14. Thin tabular aggregations of sand adhere to the lower surface of the partition, showing that it

was deposited on a bed of sand. The same phenomena are repeated in "Crow Hole" with modifications,—the cave-deposits being still *in situ*: here remains of *Ursus, Meles, Rhinoceros,* and some other forms have been found by Colonel Wood.

"Raven's Cliff" presents a cavernous fissure, broad and high externally, contracted within. Here a thin crust of stalagmite formed a floor upon sand 9 feet thick, which filled the fissure close up to the roof, leaving only an empty angular chamber about a foot high above the stalagmite. Upon the latter, remains of *Mustela foina, Canis Vulpes,* and some Fish-bones and Bird-bones were found. In the sand, large coprolites of Carnivores, some fine remains of *Felis spelæa,* bones of *Rhinoceros,* and the vertebra of a Fish were discovered. Below the sand, as usual in the Gower Caves, there was a sandy breccia cemented by stalagmite, about a foot thick. Upon it a large block of limestone, smoothed and polished, probably by the rubbing of passing cave-animals, was discovered; and patches of polished surface were seen on the walls of the cave. Remains of *Elephas, Rhinoceros, Bos,* and *Cervus* were met with above the breccia. Below the breccia was a bed of dark-grey gritty sand, indurated by calcareous infiltration, and attaining a maximum thickness of about 8 feet. In this sand, and close upon the rock-floor, teeth of *Hippopotamus major,* young and old, and remains of *Ursus, Cervus,* and *Arvicola* were met with. There was evidence, on the cliff beyond the aperture, of the cave and its contents having formerly been continued further seawards.

The author pointed out that in all these caves the bottom appears to have been first filled with sea-sand or shingle, with which were occasionally intermingled the bones of pachyderms, ruminants, &c., then living on the emerged land of Gower; that when this deposit was elevated above high-water mark, stalagmite and angular *débris* of limestone rock formed a floor, on which subsequently cave-earth or other common alluvial materials, with bones and antlers, often in profusion, were accumulated through the fissure above, during a long lapse of time after the rise had been accomplished. At last, by a converse action, of comparatively modern date, the level of the caves was depressed. The raised beach at Mewslade Bay, which appears, according to the evidence of Mr. Prestwich, to be of later date than the Boulder-clay, has without doubt partaken of changes of level similar to what the caves and their contents have undergone, although, the marine deposits in the caves not being at a uniform level, either in relation to each other or to the raised beach, it is probable that there have been locally unequal depressions of level in comparatively modern times. The author thinks that the sea has effected but a comparatively slight inroad on the cave-deposits and raised beach; and hence he infers that they belong to a relatively modern epoch,—seeing also that they are probably of later date than the Boulder-clay period, and rest on marine sands containing existing species of shells.

Paviland Cave was next referred to; but the author restricted his remarks to the remains of *Elephas primigenius* and human bones that

were found in it, and argues that the latter (*i. e.* the skeleton of the "Red Lady") are of more recent date than the former.

In the cave at Spritsail Tor (cursorily examined by Sir H. De la Beche, and thoroughly explored by Colonel Wood), under a stalagmitic bone-breccia, the irregular fissure of the rocky floor was impacted with ochreous cave-earth full of bones and teeth of *Elephas antiquus, E. primigenius, Rhinoceros tichorhinus, Equus, Sus, Bos, Cervus, Lepus, Arvicola, Mus, Ursus spelæus, U. priscus* (?), *Felis spelæa, Hyæna spelæa, Canis Lupus, C. Vulpes, Meles taxus*, and *Mustela*. Coprolites of *Hyæna*, gnawed bones of *Bos, Equus*, and *Cervus*, and a great abundance of the detached molars of Horse, gave the cave the undoubted character of having been a Hyena's den. In the superficial sand on the stalagmite, the antlers of a Reindeer and some human bones were found.

General remarks on the distribution of the Mammalian remains in the different caverns were offered, and the special anomalies pointed out; and, after a comparative review of the fauna of the Gower bone-caves in relation with that of other cave-districts of England in particular, and of Europe in general, the author arrived at the following conclusions as being consistent with the existing state of our knowledge:—

1. That the Gower Caves have probably been filled up with their mammalian remains since the deposition of the Boulder-clay.

2. That there are no mammalian remains found elsewhere in the ossiferous caves in England and Wales referable to a fauna of a more ancient geological date.

3. That *Elephas* (*Loxodon*) *meridionalis* and *Rhinoceros Etruscus*, which occur in, and are characteristic of, the "Submarine forest Bed" that immediately underlies the Boulder-clay on the Norfolk coast, have nowhere been met with in the British caverns.

4. That *Elephas antiquus* with *Rhinoceros hemitœchus*, and *E. primigenius* with *Rh. tichorhinus*, though respectively characterizing the earlier and later portions of one period, were probably contemporary animals; and that they certainly were companions of the Cave-bears, Cave-lions, Cave-hyenas, &c., and of some at least of the existing mammalia.

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2. *On some* Arrow-heads *and other* Instruments *found with* Horns *of* Cervus megaceros *in a* Cavern *in* Languedoc.

By Mons. E. Lartet, For.M.G.S.

[In a Letter to the President.]

[*The publication of this paper is deferred*].

[Abstract.]

In a cavern of the limestone at Massat, near Tarascon in Languedoc (Department of the Ariège), examined by M. A. Fontan, the floor was found to consist of a blackish earth, with large rounded

pebbles, among which were mixed, in great disorder, bones and horns of a Chamois, *Cervus pseudovirginianus*, *C. megaceros*, and *Bos*, together with implements of stone and bone, to which MM. Isidore Geoffroy Saint-Hilaire and E. Lartet have referred in the 'Comptes Rendus' of May 10, 1858.

M. E. Lartet, in his letter, has furnished drawings and descriptions of some barbed arrow-heads of bone, some having indented grooves, probably for the appliance of poison; also needles, and a flute-bevelled tool of bone, a splinter or knife of hard flint, and the horn of an Antelope hacked at the base, probably when the animal was flayed.

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3. *On the Occurrence of* CRAG STRATA *beneath the* BOULDER-CLAY *in* ABERDEENSHIRE. By T. F. JAMIESON, Esq.

[Communicated by Sir R. I. Murchison, V.P.G.S.]

[See above, page 371.]

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4. *On some small* FOSSIL VERTEBRÆ *from near* FROME, SOMERSETSHIRE. By Professor OWEN, F.R.S., F.G.S., &c.

I WAS favoured a short time since by receiving from Mr. Charles Moore, F.G.S., the discoverer of teeth like those of *Microlestes* in a probably Triassic deposit near Frome, an additional series of specimens, including, together with teeth unequivocally mammalian and having the characters of those of *Microlestes*, some vertebræ, more or less mutilated, of corresponding size, and similar mineral condition. These were discovered in a fissure containing derivations from the "Bone-bed" and from earlier (Mountain-limestone) and later (Oolitic) deposits.

A small glass tube, numbered "5," was stated in Mr. Moore's list to contain "two little vertebræ." These I first examined. One (and the most perfect specimen, figs. 1–5) is a dorsal, the other a caudal vertebra; both are biconcave (*i. e.* the articular ends of the centrum are cupped); and in both the neural arch is confluent with the centrum.

The body of the dorsal vertebra is laterally concave both vertically and lengthwise (fig. 3, *c*), the lower surface (fig. 5) being narrow, prominent, like a smooth obtuse ridge, slightly concave lengthwise, expanding somewhat, like the rest of the centrum, at the articular extremities, *c*: these are deeply cupped, of a circular figure, with a smooth, almost polished surface. A narrow parapophysis begins very near the fore part of the side of the centrum, and is continued upward and a little backward, contracted and ridge-like, to the diapophysis on the side of the neural arch, figs. 1, 2, 4, *d*; or, the par- and di-apophyses are connected by an intervening ridge. On one side there is a continuous abraded surface, which might have afforded, when entire, a single articular surface to a rib; on the other side of

the vertebra there appears to be a smooth non-articular short tract between the two expanded par- and di-apophysial surfaces, indicating that a bifurcate head of a rib had been attached to the side of this vertebra.

The neurapophyses are anchylosed to the whole length of the centrum, and incline outward, as they ascend, before bending toward and blending with each other above the neural canal, figs. 1 & 2, *n*. The arch, in breadth and height, shows diameters much greater than hose of the centrum itself; the width of the neural canal is more than double that of the body of the vertebra, indicating, therefore, either a spinal chord of mammalian proportions, or one which, as in certain lizards and fishes, was surrounded by a largely developed arachnoid and wide venous sinuses. Both the anterior and posterior margins of the arch are concave, the latter, fig. 3, *n*, most so, indicative of very wide "conjugation-holes" for the exit of the spinal nerves and blood-vessels.

The anterior zygapophyses, figs. 1, 3, 4, *z*, ridge-like at their origin,

Figs. 1–5.—*Different views of one of the small Vertebræ found by Mr. C. Moore in a Triassic* (?) *Deposit in a Fissure of the Mountain-limestone near Frome.* Magnified 8 diameters.

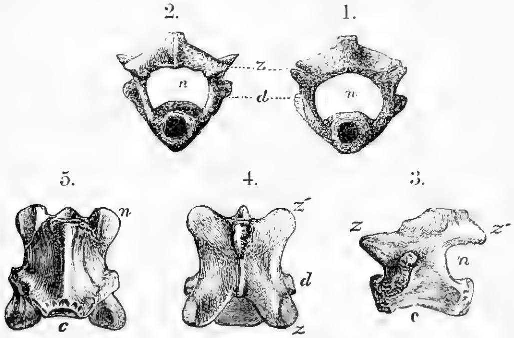

Fig. 1. Anterior view.
Fig. 2. Posterior view.
Fig. 3. Lateral view.
Fig. 4. Superior view.
Fig. 5. Inferior view.

extend obliquely outward and forward, as far as the vertical parallel of the fore part of the centrum: they form the anterior angles of the neural arch, and have their articular surfaces at the upper part, of an oblong shape, looking upward and a little inward, being very slightly concave. The anterior margin of the arch between them makes a slight projection near the process, and there describes a subangular concavity, the apex of which is at the fore part of the base of the neural spine. This spine rests on the anterior two-thirds of the mid line of the arch; its summit is broken off; behind it is a low but distinct sharp ridge, between the posterior zygapophyses. These (figs. 3, 4, *z'*) diverge, and slightly descend, projecting a little beyond the posterior surface of the centrum. The area of the neural canal

is a wide transverse ellipse, with outlets encroached on below by the convex upper border of the articular ends of the centrum. This encroaching part of the centrum contracts as it extends into the canal, and then again expands to the opposite end; so that the floor of the neural canal shows a median low rising of bone expanded at both ends, the curved depressions on each side indicating the original separate bases of the neurapophyses.

I subsequently received from Mr. Moore a few fossils from the mixed deposits of the fissure above-mentioned, including the centrum of a similar vertebra, rather smaller in size, with the median part of the lower surface less ridge-like, the part convex across being broader than in the preceding vertebra. The terminal articular cups were deep. The bases of the neural arch span outwards, as far as they are preserved, indicating the same expanse of the neural area as in the more perfect vertebra above described. The floor of the canal shows two lateral curved lines or slight depressions, with the convexities turned towards each other, and which indicate the original suture between the centrum and neurapophyses.

In the same collection was the fore part or half of a centrum with the anchylosed bases of the neurapophyses, showing a longitudinal canal on the under part of the centrum, formed by two nearly parallel, longitudinal, low but sharp ridges, which slightly diverge near the articular end. This presents a deep hemispheric cup, smooth, with sharp margins. The transverse process begins at the lower or hæmal ridge, in the form of a narrow ridge, and ascends obliquely forward to the side of the neural arch, where it becomes thicker; but the arch is broken away at this part, so that no articular surface is preserved on the transverse process, if such existed. It most probably projected as a free process; for the modification of the lower surface would indicate an anterior caudal vertebra.

With the above portion of vertebra was preserved a cupped articular end of a centrum, which may have belonged to the same vertebra.

Of the above three vertebræ the second is certainly, and the third most probably, of the same species as the first and most perfect specimen, above figured.

No known Mammal, recent or extinct, has hitherto presented the biconcave structure shown by these little vertebræ from the ossiferous fissure near Frome. But such structure is known, as a very rare exception, amongst existing Saurians; and it might be asked, since the biconcave structure was the rule among Secondary Saurians, why it may not have prevailed with the Secondary Mammals?

Hitherto we know nothing of the vertebral characters of the rare Oolitic and Triassic Mammalia; and unless the problematical vertebræ above described do belong to the little Mammal with whose teeth they are associated, we have still to learn the vertebral characters of *Microlestes*, *Amphitherium*, *Spalacotherium*, *Triconodon*, &c.

The only approach (and it is a slight one) made by Mammals to any of the Saurian characters in the vertebræ above described is, so far as I know, to be met with in the Monotremes, which offer in

the structure of their scapulo-coracoid arch so significant a departure from the Mammalian rule, and so close a resemblance to certain Secondary Reptiles. The vertebral modifications, in the *Ornithorhynchus* and *Echidna*, to which I allude, are the "slight concavity of the terminal articular surfaces" and a construction of the uniting soft parts which I discovered in 1840, and which is described and figured in the article "Monotremata," in the 'Cyclopædia of Anatomy,' vol. iii. (1841) p. 375, fig. 174. The structure is as follows:—"The articular surfaces of the vertebræ, which are slightly concave, are joined together by a thick circular band of ligamentous fibres, attached to the circumference of the articular surface, enclosing a central oblate spheroidal cavity, lined by a synovial membrane and filled with fluid."

Now, if one should look on the figure of the section of the vertebræ there given, he will see that, were ossification to extend into the fibrous basis of the synovial cup, the biconcave or amphicœlian type of vertebra would be established.

But it may be objected, in regard to another character of the little fossil vertebræ, that they show a mode of rib-articulation agreeing with the Saurian and not the Mammalian type. In Mammals, as a rule, the free rib, which has both head and tubercle, joins by the former to an articular surface common to two centrums and their intervertebral ligament. In those rare abnormal cases, however, where the ribs of the last cervical vertebræ have not coalesced as usual, but show an abnormal size as well as freedom, they articulate by both parts of the bifurcate end to the same vertebra; and here, again, the Monotremes come to our aid in an approximative appreciation of the nature of the triassic vertebræ in question. The ribs of the neck remain longer unanchylosed in the Monotremes than in other Mammals. In a young but nearly full-grown Echidna I found them, as regards bony union, "detached from all the cervical vertebræ except the atlas. The vertebral end of the cervical rib is bifurcated; the lower branch, representing the head, is articulated to the transverse process or tubercle [parapophysis] developed from the body of the vertebra; the upper branch, representing the costal tubercle, is articulated to a transverse process [diapophysis] developed from the side of the base of the neural arch" (*vol. cit.* p. 375). Such a condition of rib-articulation agrees with that indicated by the structure above described in the first and most perfect of the little vertebræ discovered by Mr. Moore.

Although the neural canal is relatively more capacious in the small Lizards than in Crocodiles, I have met with no cold-blooded air-breathing animal with anchylosed neural arch offering so large a proportionate size of the canal as in the fossil vertebræ in question. Had I known only this character of those vertebræ I should have suspected their being Mammalian, that character having served to distinguish between fragmentary specimens of large Saurian and Cetacean fossil vertebræ.

The anchylosis of the neural arch to the centrum is as common, almost, in recent Lizards as in Mammals. The vertebræ transmitted

by Mr. Moore, and above described, agree in size with that of the little mammal indicated by the unequivocally mammalian teeth. Nevertheless the depth and form of the terminal articular cups in those vertebræ, the sharpness of their margin and smoothness of their surface, accord very closely with the Reptilian structure, and hitherto have only been met with in cold-blooded Vertebrates.

Moreover, unquestionable parts of small Saurians and Fishes are mingled with the *Microlestes* teeth in this ossiferous deposit, and, indeed, predominate there.

In fact, in the last set of specimens which I received a few days ago from Mr. Moore, seven, more or less perfect, are of the partially ossified vertebræ of a small cartilaginous fish. The following is the result of the examination of these seven specimens:—

They are rings or short cylinders of bone, with a circular area having a diameter about four times the length of the cylinder, that length being from four to six times the thickness of the cylinder-wall.

This wall is of unequal length—one side, in some, being twice that of the opposite side. The first specimen shows two parallel rough surfaces, for the articulation of processes or lamellæ, either bony or gristly, bounding a probably neural canal. The cavity of the cylinder in this specimen is blocked up by matrix.

A second specimen, with the area empty, shows, besides the (neurapophysial ?) surfaces on the broader part of the ring, an opposite pair of narrower, parallel (hæmapophysial ?) tracts on the narrower part of the ring.

A third specimen shows part of the apophysis adhering to one of the parallel surfaces on the broader part of the cylinder, and extending outward as well as upward (or downward), indicating that it has bounded the side of a canal with a diameter wider than that of the centrum.

One of the broken specimens (a half-cylinder) includes the broader half, with the parallel longitudinal tracts on the outer surface, to one of which adheres the base of an apophysis extending outward.

The fifth is an entire ring, and shows the parallel longitudinal apophysial tracts on the two opposite (broader and narrower) parts of the cylinder, which is, however, a little broader where it supports the surfaces on the narrower side than at the proximity of that part.

Another entire ring has a more uniform length, or breadth, of wall than the others, and shows a small single apophysial surface at opposite sides the of ring.

The seventh specimen (a fragment) shows the ring to be a very little thicker at its ends than at its middle; and, like the others, it is quite smooth on the flattened inner surface.

There is no character of a cervical or other vertebra of a Mammalian animal in any of these specimens. Were it not for the apophyses or apophysial surfaces, they might pass for the bony rings of a windpipe, as in Birds and some Rodents. But they more closely resemble the ossified vertebral cylinders in *Heptanchus* and *Chimæra*, in which the neur- and hæm-apophyses are so far ossified as to

undergo the same conservative petrifactive change as the portions of such processes preserved in the above vertebræ.

Should the first-described cupped or amphicœlian vertebræ prove to be Reptilian, they indicate a small Saurian resembling *Cladeiodon* or *Belodon*, *Palæosaurus*, and other triassic *Thecodontia*, in certain anterior ribs being articulated by a bifurcate head to par- and di-apophyses.

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PART II. MISCELLANEOUS.

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

[The fossils referred to are described, and those of which the names are printed in italics are also figured.]

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Alphabetically arranged—the Names of the Authors in capital letters.

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

RESEARCHES *on the* ORIGIN *of* ROCKS. By M. A. DELESSE.

[Bulletin de la Soc. Géol. de France, 2e Sér. vol. xv. p. 728 &c., 1858.]

§ 1. RESEARCHES on the origin of the rocks which compose the crust of the globe date from the birth of Geology itself. Based, however, on very incomplete ideas, they necessarily led to error; hence the most extreme doctrines have prevailed in turn. Whilst Leibnitz, Descartes, Buffon, Hutton, Playfair, Sir James Hall, Dolomieu, and Desmarets attribute to the eruptive rocks an igneous origin, Bernard de Palissy, Werner, Kirwan, Mohs, and Jameson assign to them an aqueous origin. The volcanic rocks alone are, by common consent, placed without the pale of discussion, their origin being regarded as evident. In these exclusive systems, an eruptive rock is of necessity formed either by water or by fire; it seems no other alternative can be admitted.

The investigations on rocks in which for a long time I have been engaged have naturally led me to the consideration of their origin. This subject, so delicate, has been treated in our own time by eminent geologists, amongst whom I may specially cite Humboldt, Elie de Beaumont, Lyell, Murchison, Naumann, G. Bischoff, Dana, Daubeny, Poulett Scrope, Sedgwick, Phillips, Hopkins, von Leonhard, B. Cotta, Burat, Sorby, Studer, Hausmann, Boué, Keilhau, Fournet, Angelot, Virlet, Durocher, Scheerer, Bunsen, and Rogers.

The most opposite systems are still in vogue as in the first days of Geology, in a way that leaves the field entirely open to conjectures; it was easy for me then to set aside every preconceived idea, and to adopt the different hypotheses which accorded best with facts. I purpose now to give summarily an exposition of the results at which I have arrived.

§ 2. When we go back to the origin of rocks, it is necessary to investigate in the first place the different causes which have concurred in their formation. We must study, then, those which, in the interior of the earth, render rocks plastic, and in general all those which tend to develope minerals.

These causes are: heat, water, pressure, and molecular actions.

§ 3. *Heat.*—It is very evident that heat has contributed to the formation of eruptive rocks. The burning volcanos which eject their lavas in a state of igneous fusion give us an incontestable proof.

Even when the heat is not sufficient to render a rock completely plastic, it may, however, permit the substances of which it is composed to combine amongst themselves, and hence it determines the development of minerals.

When the different eruptive rocks are submitted to a strong heat, experience teaches us that they are softened and often even liquified. But in cooling they become vitrified, or at least they put on characters very different from those they displayed at first. There is no exception in this respect, any more than there is with the volcanic rocks.

Moreover, the heat necessary to melt them is higher than that of lavas. Many of the eruptive rocks are only merely agglutinated by an amount of heat which would be more than sufficient to reduce all the lavas to a complete fusion. This is the case notably in serpentine, and rocks rich in magnesia, as also in granite and rocks formed essentially of orthose and quartz.

But it is specially necessary in this preliminary study to call attention to the characters presented by the rocks which have incontestably an igneous origin. These characters are in reality well defined, and imprint on the volcanic rocks an indelible stamp.

We distinguish first of all a cellular structure, which, whether more or less visible to the eye, is always apparent when we examine a volcanic rock with the lens, and is never completely wanting. This may result either from a disengagement of gas, or it may be from a contraction of the molten matter.

We observe also that the minerals of volcanic rocks, and above all of lavas, have generally a vitreous glance. They may be, moreover, splintery, and traversed by a multitude of fissures. This may be readily verified in the felspars, amphigene, peridote, augite, and hornblende.

Now, although lavas may sometimes be very crystalline, they are generally much less so than the rocks which apparently have not been brought into a state of fusion; and even when they present very evident traces of fusion, there is always to be distinguished a residue of crystallization which envelopes their minerals, and forms what is termed their paste.

Lavas have otherwise characters which it is very difficult to define, but which will not permit them to be confounded with any other eruptive rocks. Of all the rocks, they are the most easily recognized. Hence, when an eruptive rock presents the cellular structure and traces of fusion, whilst at the same time its minerals have a vitreous fracture, we must necessarily assign to it an igneous origin, that is to say, that heat was the principal cause of its formation.

I would further remark that the eruptive rocks require generally a much greater heat than that of lavas, to be, not molten, but simply softened; that, on the other hand, rocks presenting in a very evident manner traces of igneous fusion are somewhat rare in the terrestrial crust; consequently it is only under exceptional circumstances that heat has played a principal part in the formation of eruptive rocks.

It becomes then necessary to pass under review the other causes

which contribute to the formation of rocks; and first we come to the consideration of water, which claims very special attention.

§ 4. *Water.*—When we penetrate into the interior of the earth we usually meet with water. This subterranean water forms sheets which often occur in stages one below the other, and which continue to very great depths. It represents assuredly a very notable portion of the water which exists on our planet. It is otherwise concealed; and it is without doubt for this reason that it has not attracted attention, and that geologists have not accorded to it all the importance which it deserves. It is evident, however, as Bischoff has remarked, that it must interfere in all the phenomena which take place in the interior of the earth.

Let us seek, then, to appreciate the effects of this subterranean water. In the first place, in proportion as we penetrate into the earth, its temperature becomes successively elevated; the materials which it holds in solution augment little by little with the depth; and when its temperature is very high, it ought to exercise very energetic chemical reactions on the rocks with which it is in contact. At all depths the materials which it penetrates would easily obey the molecular actions which incite them. The most favourable circumstances here, then, are found combined for the development of minerals.

The following topics are then discussed:—

§ 5. *A rock contains water when it is in the interior of the earth.*

§ 6. *A rock, fusible or infusible, can become plastic by the agency of water.*

On this latter subject the author observes: When a fusible or infusible rock is impregnated with water, it always experiences a certain softening, and sometimes even becomes entirely plastic. Reciprocally, when it loses its water it becomes on the contrary more or less lithoid.

This action exercised by water on the physical properties of rocks is extremely important, and it ought not for a single instant to be lost sight of in researches like those with which we are now occupied; for in the interior of the earth all rocks are humid, and consequently very different from what they are at the surface. The condition in which we know them in our collections is also in some sort exceptional. At a little depth, the water is moreover aided in its effects by heat and pressure; consequently these three causes combined ought to assist each other in reducing the rocks to a plastic state.

§ 7. *Pressure.*—Pressure, as Naumann rightly observes, has necessarily exerted an influence in the formation of minerals and of the rocks which compose the terrestrial crust. One comprehends indeed that in the interior of the earth the rocks are subjected to a very considerable pressure, owing to the thickness of the strata which cover them.

If one considers now the eruptive rocks, they must have sustained considerable pressures resulting from the force itself which elevated them to the surface. They have also been compressed by the lateral pressures produced upon their walls by the enclosing rock.

The upheaval of mountains, which has taken place sometimes on a gigantic scale, and which has brought up to the surface rocks from a very great depth, has above all developed enormous pressures.

Whether the pressure may have been permanent or casual, it is certain that it has changed the characters of the rocks upon which it has been exercised; it has altered their physical properties. On the other hand it has produced similarities in contiguous rocks; it has permitted the play of molecular actions and the development of minerals; consequently it has modified also the mineralogical composition of rocks.

In researches upon the origin of rocks, it is necessary, then, to take it into account, and its effects are to be added to those of heat and water.

§ 8. *Molecular actions.*—The molecular actions have also contributed, it may be, to form the rocks, or it may be to metamorphose them. However, it is proper to consider them only as secondary causes; for they appear to be principally brought into play by heat, by water, and by pressure. Electricity itself, which accompanies and incites molecular actions, appears to result from those primary causes.

It is the molecular actions which engender the minerals composing the rocks. They are exercised moreover whether the mineral substances are in a gaseous, liquid, or solid state.

§ 9. *A similar mineral may have an aqueous or an igneous origin.*—Great importance has been attached, and rightly, to the artificial production of minerals; and by means of very ingenious methods it has been attempted to make them crystallize with the characters which they present in nature.

It ought to be remarked, however, that it is not by any means necessary to reproduce a mineral to be assured that it had an aqueous or an igneous origin. Thus when minerals, such as quartz and calcite, have crystallized in stratified rocks enclosing fossils which could have lived only in water, one cannot refuse to them an aqueous origin; similarly minerals, such as augite and peridote, which are developed in the lavas ejected now by active volcanos, have incontestably an igneous origin.

Since the clever experiments of Sir James Hall, researches on the artificial production of minerals have been greatly multiplied, and often crowned with success. Amongst the *savans* who have undertaken them of late, I may mention specially, Hausmann, Mitscherlich, Berthier, Fuchs, von Leonhard, Becquerel, Ebelmen, de Sénarmont, Daubrée, G. Bischoff, Wöhler, Bunsen, Percy, Durocher, Manross, B. Cotta, Charles Deville, Damour, Caron, and especially Henry Deville.

But the bearings of the results obtained have been frequently exaggerated; for from the fact that a mineral had been obtained by the dry way, or by the wet, it has been generally concluded that it had an exclusive mode of formation.

It is easy to see, however, that a similar mineral may have had at one time an aqueous, at another time an igneous origin.

It is otherwise easy to comprehend why it is so; for the chemical and molecular actions which give rise to the mineral are exerted it may be in the presence of heat, or it may be in the presence of water.

But, by a fortunate circumstance, an identical mineral presents great differences in its characters according to the rocks in which it has been developed.

It suffices, to appreciate these differences, to compare the vitreous orthose of trachyte with the orthose of granite; the augite of volcanic rocks with the pyroxene-diopside, or sahlite; hornblende of basalt and of phonolite with the amphibole-tremolite, or actinote; the peridote of lavas with batrachite.

The decidedly special characters that each mineral takes, according as it is formed in the presence of heat or in the presence of water, will thus reveal its origin.

§ 10. *The order of solidification of the minerals which compose a rock is not that of their fusibility,* is then considered.

§ 11. *The characters of a rock depend on its chemical composition and its origin.*—When one studies the eruptive rocks, it is easy to discover that their chemical composition is simple, and moreover but little varied. They contain generally silex, alumina, oxide of iron, magnesia, lime, potash, soda, and water. Other substances are present, but in a very slight proportion.

The comparative examination of analyses of rocks teaches that, when they have the same chemical composition, they may notwithstanding present very different physical characters.

Thus the composition is sometimes the same in trachyte and granite, in basalt and trap, and in granite and eurite. But if trachyte encloses the minerals of granite, it is well distinguished from it by its cellular structure and by the vitreous lustre of its felspar. Well-marked differences exist equally between the other rocks which I have cited; and although their composition might be identical, no geologist would ever confound them.

It is necessary to go back to the very origin of these rocks to find the explanation of their differences. At the same time that heat, for example, accounts for the cellular structure and vitreous lustre of trachyte; water, pressure, and molecular actions give, on the other hand, to other rocks the characters which distinguish them.

The differences presented by rocks having the same elementary composition are due, then, to their origin. Consequently if the chemical composition of a rock exerts a great influence upon its characters, the causes which have presided at its formation exercise apparently a still greater.

§ 12. *An eruptive rock which contains water is not necessarily decomposed.*—When an eruptive rock is decomposed, it generally contains water. Thus it is easy to see that the granitic or trappean rocks pass first into a state of sand; afterwards, proportionately as the decomposition of their felspathic parts progresses, they take up a greater quantity of water; and lastly, they become changed either into clay, more or less impure, or into kaolin. It thus is certain that their quantity of water is augmented. If they contain carbonates,

the inverse takes place, and the quantity of these carbonates diminishes.

But is it permissible to conclude from these facts that whenever an eruptive rock contains water it has been thereby decomposed? I think not, and I regret to find myself in disagreement on this point with some eminent French and German geologists.

§ 13. *An eruptive rock has most commonly a complicated origin.*—The study of volcanic rocks shows that the definition of *igneous* or *aqueous* rocks cannot be exact. It is necessary to give to these words a different signification from those which they have in ordinary language. Thus, when we say of a rock that it had an *igneous* origin, it is not meant that it had been brought to a state of fusion by heat alone: similarly of a rock of *aqueous* origin, that it will only become plastic by the action of water. It must be understood that these expressions have regard only to the *principal agent* in the formation.

I repeat, that although heat or water may well play a predominant part in the formation of an eruptive rock, in no case is this agency exclusive; it is accompanied by other agents, especially by pressure, and in general by the very various forces which can incite molecular action.

Rocks assuredly present very different characters according to the causes which have presided at their formation; but when these causes are multiple, the characters become intermediate and much less defined. The principal causes—heat, water, and pressure—are usually found combined.

It is then very certain that an eruptive rock can have a mixed and very complex origin. Is it then astonishing after this, that interminable discussions have been raised amongst geologists when they have tried to explain the origin of rocks? and is it not evident that the problem was not always to be solved on the terms within which it was restricted?

§ 14. *Eruptive Rocks.*—The preceding general considerations permit us now to examine the origin of different rocks.

Heat imprinting its peculiar mark upon those rocks which it has contributed to form, it is natural to group rocks according to the importance of the part it has played. They may be thus divided into three classes, according as they are *igneous*, *pseudo-igneous*, or *non-igneous*.

I. Igneous Rocks.

§ 15. The igneous rocks have been reduced to a state of fusion, or at least rendered plastic, by heat. They are almost always anhydrous. They have a cellular structure, and to a certain degree are rough to the touch. The minerals they contain have a decided and characteristic vitreous glance. They form the rocks which are considered as eminently volcanic; they often occur as lavas, and have preserved traces of fusion.

Their extreme types are trachyte and dolerite, which represent all their qualities.

§ 16. *Trachyte.*—This is a rock which, according to M. Naumann, contains orthose, anorthose, ferro-magnesian mica, and hornblende. Quartz also occurs in it. These minerals are disseminated in a cellular and rough paste, which is generally of a grey, white, or reddish colour. The orthose is splintery, transparent, and has a bright vitreous fracture which gives it a peculiar character; it contains numerous fissures parallel to the length of the crystals. It differs so much from the nacreous orthose of granite, that mineralogists consider it as a distinct mineral, and have given it the name of vitreous orthose, or of ryakolite, or sanidine.

The ferro-magnesian mica occurs in well-defined crystals of a brilliant black, or very dark brown colour. It is never accompanied by the silvery white aluminous mica which is found in granite, gneiss, and mica-schist.

The hornblende is black, and rarely of a blackish-green colour. Its crystals are well formed, elongated, and even complete at both extremities; they have a bright glance, and their lamellar structure is very characteristic.

The quartz is rare when the trachyte is very cellular, viz. when it bears evident traces of fusion. On the other hand it is abundant when the trachyte has a more compact structure, and approaches more nearly to quartziferous porphyry. Moreover the examination of trachytic districts shows frequent passages between quartziferous porphyry and trachyte containing quartz.

The fissures of trachyte are often covered with crystals of specular oligist-iron; sometimes the rock is completely impregnated with them. It also contains chlorhydric acid, sulphur, and sulphuric acid. It is important to note the presence of these substances, as we see rocks thrown out by modern volcanos impregnated with them.

Some trachytes also contain zeolites: those of Hungary are also often traversed by veins of opal; they are then not quite anhydrous, and consequently water has not been altogether absent in their formation.

With regard to its chemical and mineralogical composition, trachyte is closely connected with granite, from which it differs principally by its cellular structure and the vitreous glance of its constituent minerals; but in proportion as these characters disappear, a group of intermediate rocks is produced which contain more and more quartz, and in which the influence of heat appears to have been gradually diminishing.

Some writers, as Desmarets, de Saussure, Dolomieu, and L. von Buch, have supposed that the action of the volcanos of Auvergne on the granitic rocks amongst which they have burst forth might have produced trachyte. According to this hypothesis, trachyte would be to a certain extent the product of granite re-heated and metamorphosed.

After observing (p. 754) that pressure is not essentially necessary to the formation of trachyte, and that it is often accompanied by thick beds of conglomerate on a large scale, he sums up his observations on this rock thus:—

Trachyte presents all the characters of an igneous rock; it has been melted, or at least softened, and rendered plastic by heat. When it is filled with quartz, we see its distinctive characters gradually disappear, and it passes insensibly into porphyry: there is every reason to believe that heat, then, plays a less and less active part in its formation.

§ 17. *Dolerite.*—Dolerite, if we give this name to the lavas with anorthose and anhydrous ejected by volcanos, offers in a still more decided degree the characters of an igneous rock.

It is formed of anorthose and augite; sometimes it contains peridote, mica, and amphigene (or leucite). These minerals are disseminated in a grey or blackish anhydrous paste, more or less magnetic, and cellular. When this paste predominates and is very cellular, the dolerite passes into a scoria.

The anorthose has a vitreous lustre; it is white, translucid, and laminated. It never assumes a greenish colour and a fatty lustre, as in basalt. Consequently there is the same difference between the anorthose of dolerite and that of basalt, as between the orthose of trachyte and that of granite.

The augite is black or blackish-green, in crystals terminated at both ends. It has also a glassy lustre, as is likewise the case with the peridote and amphigene.

The author further on observes: There can be no doubt respecting the mode of formation of the rock to which I here give the name of dolerite; for it is actually ejected by several existing volcanos. Thus the lava of Etna contains labrador and augite; that of Vesuvius contains amphigene, augite, and peridote. Dolerite has therefore been reduced to the liquid state by the action of heat. To this therefore the word "lava," by which several kinds of volcanic rocks are described, should be specially applied.

§ 18. Trachyte and dolerite offer us two types of igneous rocks, the origin of which is well known, since we can see them formed in existing volcanos. They contain no appreciable quantity of water; for that which they may have contained has escaped by means of *fumarolles* at the moment of their solidification. This water moreover has spread itself through the cavities and fissures of the eruptive rock itself, and to a certain distance in the neighbouring rocks. It has produced chalcedony, opal, hyalite, quartz, carbonates, zeolites, and generally all the minerals which fill the cavities of the amygdaloidal rocks. Thus the effects of heat may be complicated by those of water, even when the eruptive rocks are igneous and anhydrous.

II. Pseudo-igneous Rocks.

§ 19. Pseudo-igneous rocks have been reduced to a state of fusion partly igneous, partly aqueous. Water, heat, and perhaps also pressure, have all helped to make them plastic. They are always in the state of hydrates. They have often also a cellular structure; but their minerals have only a very slight vitreous lustre. They separate into prisms, or rather spheroids. They are generally associated with igneous rocks, and they are chiefly met with in volcanic districts.

The types which I shall describe in the two felspathic series are *retinite* and *basalt.*

§ 20. *Retinite.*—Retinite contains vitreous orthose, ferro-magnesian mica, and also quartz. These minerals are disseminated in a paste which is itself entirely vitreous, and which forms the greatest portion of the rock.

The paste has a glance at once vitreous and resinous, which is characteristic of retinite (pechstein); it is often cellular, and the colour varies from red and brown to green and dark black. It always contains a large proportion of water, sometimes as much as 10 per cent.

Obsidian may also be considered as a variety of retinite, in which there are only slight traces of water and bituminous or organic matter: in a complete classification of rocks it ought therefore to be placed at the extreme limit of the hydrated igneous rocks.

The minerals enclosed in retinite are the same as those found in the cavities of trachyte. There is especially much silex in the state of opal, chalcedony, and quartz. Zeolites also occur.

The absence of carbonates in retinite, which deserves special notice, is doubtless owing to the fact of the retinite being in a vitreous state. Carbonates are generally wanting in those eruptive rocks which are rich in silex, even when they are hydrated.

Retinite is frequently found in volcanic regions, where it is often associated with trachyte and also basalt. It forms well-characterized veins; and it is evident that it was completely plastic at the time of its eruption.

After describing the different positions and modes of occurrence of retinite, the author continues:—

Phonolite differs much from retinite in its physical properties; nevertheless these two rocks contain vitreous orthose, and are hydrated; they are moreover associated with trachyte, so that they represent two different states of hydrated trachyte.

The study of retinite and all the rocks belonging to the class of vitreous trachytes shows us that these rocks are of mixed origin, and result from the combined action of heat, water, and probably also of pressure. They preserve, it is true, the characters of the igneous rocks, but, instead of being anhydrous, are hydrated; water, then, has played an important part in their formation.

§ 21. *Basalt.*—Basalt is then considered; and the author comes to the conclusion that all the properties of basalt distinctly show its mixed origin, and that heat and water have contributed to its formation. It has really undergone an "aqueous fusion." Its temperature was sufficiently high to permit the development of peridote and augite, but not sufficient, however, to completely disengage the water and volatile substances. We can understand thence why basalt is so often associated with lavas, and why we observe it at great distances from all kinds of volcanos. It should not be inferred, however, from the water it contains that its eruption was submarine; it was formed, on the contrary, in the interior of the earth.

§ 22. *Trap.*—At the end of the pseudo-igneous rocks is trap. Closely as it is allied to basalt, I think it differs from it in having

had a less elevated temperature. Thus has resulted the absence of peridote, the presence of a great quantity of carbonates and zeolites, and, above all, that the metamorphism exerted was less energetic.

On the other hand, as the trap was completely fluid, I am led to believe that it formed at the moment of eruption a kind of mortar or miry paste.

It is probable that it then contained a much greater quantity of water than the water of crystallization which it has retained: to this water it owed its great fluidity. It was only when its crystalline structure was developed that it became lithoid, and that it took on thus its hardness as well as its cohesion.

I would remark, however, that the veins of trap may very well be more or less argillaceous. There are some even having all the characters of true clays; it has been always considered that these had been decomposed and changed into a kind of kaolin. But to me it seems that the trap has been preserved also in the state of muddy paste; for the characters taken by this paste must necessarily depend much on its chemical composition: consequently whenever it was rich in alkalies, for example, it became felspathic and very hard; whilst in the contrary case it could not well be solidified, but would remain always in the state in which it was erupted.

III. Non-igneous Eruptive Rocks.

§ 23. The igneous and pseudo-igneous rocks represent those which we ordinarily term *volcanic*. The non-igneous rocks which we now study correspond to the *plutonic* rocks of Lyell. Their component minerals have no longer the vitreous glance peculiar to igneous rocks. Their structure is no longer cellular, usually even it is very compact. Lastly, they are not associated with volcanic rocks, and consequently they ought to have altogether another origin. It is really water and pressure which has rendered them plastic; for heat has only played a secondary part in their formation.

§ 24. *Granite.*—After giving in detail his views of granite, the author sums up: It seems to me that granite presents none of the characters of igneous rocks. For the development of its minerals it was sufficient that it formed a magma slightly plastic, the study of the granites of some localities showing even that it could crystallize in nearly a solid state. Water, assisted by pressure, has most probably contributed in the most efficacious manner to render granite plastic. Heat has likewise assisted; but it was very moderate in degree, and certainly much below redness. If we suppose the granite to have attained a sufficient state of plasticity, it is evident that in other respects the crystallization of its minerals has been determined by chemical and molecular actions.

§ 25. *Diorite.*—Opposite the granitic rocks it is proper to put the trappean rocks, in which the felspathic anorthose is associated with mica and with hornblende, that is to say, with those minerals which we find in granite. I shall consider specially diorite, which is one of the most widely spread and most important rocks.

After noticing its characters, the author says: "Diorite approaches

closely to granite in its mineral composition; for its constituent minerals occur in granite, and moreover its accessory minerals are also there met with. It has sometimes a well-developed crystalline structure; its metamorphism is analogous to that of granite; and it sometimes passes insensibly into that rock, with which it is very often associated.

"I think then that diorite is formed under conditions intermediate between those producing trap and granite; but in the generality of its characters it is essentially allied to granite, and consequently it has been chiefly engendered by water and pressure, the part played by heat being very subsidiary. Kersantite and euphotide may have had a similar origin; whilst hypertite and melaphyre tend towards trap, and even basalt, conducting thus the transition into the volcanic rocks."

§ 26. *Serpentine.*—More inexplicable than all other eruptive rocks, serpentine remains to the present hour a perfect enigma.

The preceding investigations have completely familiarized us with the idea that an eruptive rock may be hydrated. If in the pseudo-igneous rocks, such as retinite and basalt, water and heat have played the principal parts; in serpentine the effects due to heat have nearly disappeared, so much so that the plasticity of the rock can hardly be otherwise attributed than to water and pressure.

In conclusion, serpentine is very tender and highly hydrated; it is associated with diorite and euphotide, into which it passes insensibly. I think then that its origin is the same as with these.

§ 27. *Résumé.*—The chemical composition of rocks having very different external features may be the same; for the characters which are proper to them not only depend on their composition, but still more on the agencies which were exerted at the period of their formation. We can thus understand how rocks having the same composition, and yet different from each other, have been produced at the same geological epoch. One comprehends also why, reciprocally, a like rock has been erupted at different epochs.

The origin of rocks has given rise amongst geologists to interminable discussions, in which the most opposite doctrines have apparently triumphed in their turns. These fluctuations, sometimes very abrupt, are explained by the exclusive importance attached to one or other of the agents which have combined in the formation of rocks. It is assuredly very difficult to make out the part which each agent has played; but it seems to me that the developments into which I have entered lead one to repeat, with M. Agassiz*: "After all, the truth, as it so often happens, is here found to be between the different systems. The different agencies to which each party refer the results have all exercised their influences." [W. J. H. and T. R. J.]

* "Système Glaciaire. Nouvelles études et expériences," 1re partie, p. 572.

On the Geology *of* Carinthia *and* Istria. By Dr. Stache.

[Proc. Imp. Geol. Instit. Vienna, Jan. 11, 1859.]

The portion of these provinces surveyed by Dr. Stache during the summer of 1858 comprises the territories of Cosina, Concedo, Pinguente, Castua, and San Stefano, Inner Carniola between the Valley of Wippach, the River Poik, the Lake of Zirknitz, and the bogs around Laibach. Observations made in excursions between Gorice and Trieste, along the Laibach-Trieste Railroad, and into the Karst, are also added. The geological formations constituting this region are :—

I. *Alluvia* and present deposits in the extensive peat-bogs near Laibach, along the Isonzo and its affluents, in the large plain S.W. of Gradisca, and on the western shores of the Gulf of Monfalcone and Trieste. In the valleys on the western banks of the Recca, the small rivulets, when transitorily swollen by continuous rain or melted snow, accumulate cones of materials torn from the sandstones and marls through which they take their course.

II. *Diluvia.*—These acquire some importance in the gravels extensively deposited along the Isonzo, between Gorice, Cormony, and Gradisca, and in the loams of Copriva, Massan, and Biglia. They are represented in the rest of the territory by—1, sporadic deposits of red ferruginous loams, originating in the destruction of Werfen-strata, and filling the clefts and caves in more ancient limestones; 2, by pisiform iron-ores, derived from the detritus of pyritiferous Eocene marls; and 3, by secondary deposits of alum-ores in the cavities of Upper cretaceous limestones.

III. *Eocene Deposits.*—A. Superior or Tassello Group. This consists of alternations of thick-bedded solid sandstones associated with thin layers of marl, and thick beds of marl or marl-slates, including seams of sandstone. The strata are frequently folded and rolled up, and so appear thicker than they really were in their normal horizontal position. Except Fucoids, indistinct remains of carbonized plants, and local accumulations of carbonized stems and branches, this group shows no traces of former organic life. It is well developed on the banks of the Rivers Recca, Poik, and Quieto in the Wippach valley, and along the shore between Trieste and Pirano.

B. Middle or Nummulitic Group.—This occurs rather constantly between the upper group A and the Lower Nummulitic group, in the shape of a conglomerate of solid Nummulitic limestones, of large fragments of older Nummulitic deposits, or of Nummulitiferous nodules, imbedded in a soft marly cement. Where they overlie the Tassello group it is only in consequence of local disturbances, the effects of which are visible in the frequent and various foldings of the whole group. *Nummulites* and other *Foraminifera*, and casts of Bivalves, Univalves, and *Echinidæ* are of frequent occurrence. The lowermost persistent stratum is a narrow zone of bluish or yellowish, somewhat slaty limestone, with Fucoids (Trieste-Optschina) and *Crustacea* (Sterna). This group is most conspicuous on the margins of the Recca Valley, around Pinguente, and near San Stefano.

C. Inferior or Great Nummulitic Group. This is composed of limestones in strong bedded masses, or in thinly foliated calcareous slates, sometimes of considerable hardness. Their colour is white or light-yellow, or grey passing into dark-grey and black in the thicker layers. Their development throughout the whole of Istria is very conspicuous; and they may be subdivided, according to the nature of their organic remains in general (Corals, *Terebratulæ*, *Alveolinæ*, *Echinodermata*), and the species of *Nummulites* included in them, into several subgroups, each of them constantly keeping a fixed horizon.

D. Lowermost or Freshwater Group. Its strata are interposed between the group C and the uppermost Rudista-limestones. Their lowermost horizon is marked by grey or brown bituminous limestones, with lenticular coal-beds, large freshwater shells, and fruits of *Chara*, most constantly overlain by hard smoke-grey limestones, containing small freshwater Gasteropods, and, in some localities, an enormous quantity of *Chara*. Dr. Stache gives to these strata the name of "Cosina-Vrem Strata," from the places where they occur most conspicuously, and he thinks them to be old Tertiaries, corresponding with certain portions of D'Orbigny's "Suessonien inférieur" (Calcaire lacustre de Rilly).

IV. *Cretaceous Rocks.*—These are very prevalent within the territory in question, and may be subdivided, although with some difficulty, into three more or less distinct groups:—

A. Superior Rudista-group, comprising limestones, of compact or slaty texture, and calcareous breccia, generally of white or clear colours, and including *Hippurites* and *Radiolites*, throughout their range in Istria, as a nearly constant narrow zone on the margin of the Nummulitic deposits. Near Kaal they are almost entirely composed of fragments of *Cidarites* and other Echinoderms.

B. Middle or Radiolite-group, comprising generally dark-coloured limestones, dolomitic limestones, and dolomitic breccia, with sometimes a strong bituminous smell. They admit again of subdivision into—1. An upper series, in which prevail limestones, alternating with dolomitic arenaceous strata, and including in enormous quantities a long and slender species of *Radiolites*. 2. A lower series of breccia and sandstones, of essentially dolomitic character, rarely including organic remains, or subordinate limestone-beds. These two series together constitute the plateau of the Schneeberger-Wald, the Schneeberg itself (5673 ft.), the N.E. portion of Istria, and all the Karst region.

C. The Inferior Rudista-group; with two subdivisions:—

1. Upper series composed of limestones in laminæ, with corneous silex, and marly, dark-coloured, bituminous, calcareous slates, known long ago to yield a few remains of Fishes near Comen and in some other localities.

2. A lower series of undoubtedly Neocomian origin, which may be also called Caprotina-limestones, on account of a species of these bivalves (probably *Capr. ammonia*) occurring very frequently in the yellow or grey limestones composing it. This group may be distinctly traced along the railroad from Laase to Loitsch.

The group A may be parallelized with D'Orbigny's "Senonien;" the group B with his "Turonien;" and the group C with the Upper Neocomian.

V. *Trias.*—This is wanting in Istria, but is conspicuously developed in Inner-Carniola, bordered by the Cretaceous group in a direction nearly parallel to the line of fracture running through the Planina, Zirknitz, and Baha Valleys. It may be divided into three subgroups:—

A. The Upper Trias, with prevailing greyish limestones and siliceous and sometimes striped dolomites, with traces of repeated disturbances. Its fossil remains are *Chemnitziæ* and (especially in the intercalated reddish marl-strata) numerous individuals of *Megalodus Carinthiacus*, *Corbula Rosthorni*, and other forms characterizing the "Raibl-beds." The limestones, nearly everywhere associated with the Megalodus-strata, are full of the shells of a large bivalve (*Ostrea*), so solidly impasted in the limestone that specimens sufficient for generic determination are scarcely to be obtained.

B. The Middle Trias, consisting in descending order of—1. Black limestones, full of *Pentacrinites*, with some few small Brachiopods. 2. Fine-oolitic limestones, with numerous small Gasteropods and Bivalves, characterizing them as analogous to the St. Cassian strata. 3. A series of dolomitic strata, of considerable thickness.

C. The Lower Trias, exhibiting in descending order—1. Dolomite, in thin strata, alternating with corneous silex and variegated marls. 2. Variegated marl-slates and red sandstones, with thin strata of dolomite, yellowish and grey sandstones and slates, bearing the palæontological features of the Werfen-strata.

VI. *Carboniferous Group.*—(Gailthal-beds: conglomerates, slates, and sandstones); confined to some few localities, and nowhere extensive. [Count M.]

On the Tertiaries *and* Porphyries *of the* Sann River, Lower Styria. By M. Th. Zollikofer.

[Proceed. Imp. Geol. Instit. Vienna, January 25, 1859.]

These Tertiaries, deposited in the depressions of rocks of more ancient date, are remarkable as including a great quantity of Brown-coal, and as being intermediate in age between the Eocene and Neogene periods. Besides the impressions of leaves bearing an Eocene character, as those of Potzka, no fossil species occurring in them is decidedly Eocene or Miocene, some of them (as *Cerithium margaritaceum*) being rather indicative of an Oligocene origin.

In connexion with these Tertiaries, solid porphyries and porphyritic tuffs make their appearance, which, although known long ago, have been the subject of many controversies. M. de Morlot supposes them to be partial metamorphoses of the sedimentary rocks with which they are sometimes alternate. Dr. Rolle admits the eruption of solid porphyry, subsequently destroyed and regenerated into tufaceous layers. According to M. Zollikofer's local observa-

tions, the porphyries are contemporaneous with the Werfen-strata. The tuffs are either tufaceous sandstones intimately connected with the porphyries themselves, and therefore contemporaneous with them, or of an aspect resembling silex, and evidently Tertiary beds metamorphosed by the contact, or at least the proximity, of the porphyries, in a way still unexplained. Near Tüffer the Tertiary marl-slates next to the porphyries are abruptly metamorphosed into corneous silex or tufaceous sandstone. [Count M.]

On the Geology *of* North-western Bohemia. By M. Jokély.

[Proceed. Imp. Geol. Instit. Vienna, January 25, 1859.]

The mass of the Iser-Gebirge, representing the central nucleus of the Sudetian mountains, is granitite, a compound of oligoclase and interspersed binary crystals of constantly pale-reddish orthoclase. Granite is but of secondary occurrence, either as fragments impasted in granitite, or distributed in irregular masses among the gneiss surrounding the southern slope of the granitite, or rising as so many islands above the diluvial deposits.

The Jescken Mountain-group joins the Iser-Gebirge on the south-east. Its chief constituents are argillaceous slate, with local beds of quartzite, granular limestone, amphibolic rocks, and greywacke-like slates with intercalated gneiss, probably of eruptive origin. Manifold irregularities in the stratification of these rocks may be ascribed to a pressure which has acted on them in the direction from N. to S.

Granite, with two distinct species of felspar, mica, and a dichroït quartz (Prof. Cotta's "Rumburg-granite") is the essential constituent rock of the Rumburg-Hainspach Mountain-group. Another variety of granite, with pale-reddish felspar, resembling imperfect granite, forms local masses within the prevailing variety. Greywacke and gneiss, with veins of galena and pyrites, like those of the Jescken, and here and there amphibolic slates, are locally included in the granite, being probably large fragments torn away from the Jescken schistaceous masses, and essentially different from the veins of massive diorite-like amphibolites running locally through the granitic rocks.

From the circumstance of crystalline slates and gneiss everywhere conformably overlying the granitite, this rock may well be supposed to be the efficient cause of the last upheaval in the Sudetian mountains. Granite, far less diffused, and having evidently taken but a very secondary share in this convulsion, is undoubtedly of more remote date than the granulite. The steep upheaval of the Old Red of Liebenau and of the Cretaceous deposits ("Quader") along the border of the Jescken, and further off, may be of still less remote date, being confined to a very limited space; rolled fragments of granite moreover occur in the Old Red conglomerate, lying between melaphyre and porphyry. [Count M.]

Fossil Salamandridæ *of* Bohemia. By Dr. H. von Meyer.

[Proceed. Imp. Geol. Instit. Vienna, March 29, 1859.]

M. Jokély found in the summer of 1858 in the basaltic tuff of Alt-Warnsdorf (N. Bohemia) the remains of a Batrachian (belonging to the *Salamandridæ*) nearly approaching to the *Triton opalinus*, H. v. Meyer, from Leschitz (Bohemia). The head and anterior part being wanting in the Alt-Warnsdorf specimen, the generic determination remains still uncertain. This specimen (*Tr. basalticus*, H. v. Meyer) differs from *Triton opalinus* by its stronger tibiæ, by the proportions of the vertebral and caudal processes, and by the presence of a tail, wanting in *Tr. opalinus*; and from *Salamandra basaltica*, from Markersdorf (N. Bohemia), by the proportion of its tibia and femur. The Rhenish Brown-coal yields two species of *Salamandridæ* (*Salamandra Ogygia* and *Triton Noachicus*), both unknown in the analogous Tertiaries of N. Bohemia. *Palæobatrachus Goldfussi*, however, occurring plentifully both in the Rhenish and in the Markersdorf Brown-coal, it may be considered that these deposits are coeval. [Count M.]

Metallic Lead *in* Basaltic Rocks. By F. Ritter von Hauer.

[Proceed. Imp. Geol. Instit. Vienna, March 29, 1859.]

Professor Redtenbacher and Baron Ch. Reichenbach found in a specimen of greywacke-like basaltic tuff from Rautenberg (N. Moravia), intended for chemical analysis, one larger and five or six smaller metallic grains, firmly adhering to the stony mass and offering all the physical and chemical characters of metallic lead. Dissolved in nitric acid, this substance gave perfect crystals of nitrate of lead; and sulphuric acid produced in the solution a copious white precipitate, blackening with sulphuret of ammonia, but not soluble in it.

The occurrence of native lead is extremely rare; the only authenticated instances of it are a specimen with oxide of lead, from Perote (Vera Cruz), brought to Europe by Mr. Stein, some minute scales and globules, discovered by Dr. Ferrenner in 1853, in the auriferous sands of Olah Juan (Transylvania), and a similar occurrence in the gold-sands of Leontjewsky (Ural mining district). [Count M.]

On the Fossil Fishes *of the* Austrian Empire. By M. Steindacher.

[Proceed. Imp. Acad. Vienna, July 14, 1859.]

Six new species have been described by M. Steindacher. The first of them, *Aipichthys pretiosus*, a new genus of the (at present tropical) family *Vomeridæ*, occurs in the dark slates of Camen in Istrian Karst. The second, *Strinsia alata*, from the tertiaries of Szakadat (Transylvania), is the first known fossil species of a genus the only known recent species of which (*Str. Tinca*) lives on the Sicilian coast. Of the four others, all from the Tertiaries of Pod Sujed, near Agram (Croatia), one is a *Scomber*, the first fossil representative of the genus, and whose nearest recent ally lives in the Indian Seas; and the others belong to the genus *Chætoëssa*, hitherto unknown in a fossil state. [Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Kössen Strata *in* North-western Hungary. By M. Sturr.

[Proceed. Imp. Acad. Vienna, December 1, 1859.]

Suess, Oppel, and Rolle have already treated of the Kössen Strata, the parallelism of their Alpine representatives with their Extra-alpine "Bone-bed," and their geological position with respect to the Keuper and Lias. The parallelism between, and contemporaneity of, the Kössen-beds and the Bone-bed have been well proved. Their geological position, however, is still controverted. The geologists of Vienna have considered the Kössen Strata to be Liassic; whilst others, especially of late, regard them as being the uppermost subdivision of the Keuper-series. This question, unimportant or not to be solved in some cases, may be easily answered as respects the Kössen Strata. If, indeed, the *Acephala* occurring both in them and in the sandstones of the Bone-bed bear a greater resemblance to those of the Trias; their *Brachiopoda*, which are of greater geological importance and specifically recognizable, are referable only to those of the Lias. *Ammonites planorbis*, a genuine Liassic form, occurs in the Kössen Strata. Other species are known to pass from the Kössen-beds into the overlying Lias; the strata always have such markedly transitional characters, that the former could not be regarded as Keuperian without doing violence to well-established facts.

In Hungary the Kössen-beds rest immediately on the Red Sandstone of the Carpathian Mountains; this sandstone, like the analogous deposit in N.-E. Bohemia, includes masses and interstratified layers of melaphyr and amygdaloid. The Werfen-slates occur only at one place in the eastern portion of the district. The Upper Trias is wanting in N.-W. Hungary. It may hence be inferred that the Carpathians formed a continental area, and remained so for the whole interval from the deposition of the Red Sandstone to that of the first of the Kössen-beds; and that previous to the formation of the latter some convulsive movement must have newly exposed a portion of the land to the action of the sea. This disturbance gave a new direction to the subsequent deposition of inorganic matter and development of the organic forms; which also affords an argument in favour of the Liassic relation of the Kössen Strata. [Count M.]

On Hoernesite; *a* New Mineral Species. By Prof. Kenngott and Director Haidinger.

[Proceed. Imp. Acad. Vienna, March 8, 1860.]

When at the Vienna Imperial Museum, Prof. Kenngott (now at the University of Zurich) had recognized this new species and proved it, by blowpipe, to contain magnesia and water and an acid of a doubtful nature. Lately he transmitted to Dr. Hörnes the

preliminary results, leaving to him and Dr. Haidinger the denomination of this new species. Dr. Haidinger chose the denomination of *Hoernesite*, indicative of the friendly and scientific intercourse between the discoverer and his former collaborator at the Imperial Museum.

Hoernesite ranks among the "Haloids" of Mohs's system, and appears in spheroidal groups of crystals, developed within the free interstices into small rhomboid lamellæ, with an acute angle of 36°; which Dr. Haidinger regards as belonging to the Augitic (Mohs's "Hemiprismatic") system. The crystals are white and flexible, with a single cleavage-plane of pearly lustre, parallel to the longitudinal surface. The hardness is equal, or perhaps inferior, to that of talc (1·0 of Mohs's scale): specific gravity=2·474. According to Chev. Ch. de Hauer, the electro-negative element is arsenic acid, and the chemical formula is $3MgO.AsO^5+8HO$ (arsenic acid, 46·33; magnesia, 24·54; water, 29·07; loss, 0·06).

The only specimen at present known came to the Imperial Museum with the celebrated collection of Van der Nüll, and has been mentioned by Mohs, in the description of this cabinet, under the denomination of talc, to which, and especially to its variety with stellar fracture (known as "pyrophyllite"), it bears indeed a striking resemblance. This specimen is said to come from the Banat, probably from the environs of Oravicza. The new species is particularly interesting as filling up a blank in the series of the hitherto known native arseniates of copper, iron, cobalt, and lime.

[Count M.]

On the Geology *of* Tahiti *and* Taïarapoo. By M. Kulczycki.

[Proceed. Imp. Geol. Instit. Vienna, December 13, 1859.]

Dr. Scherzer sent to Director Haidinger a note from M. Kulczycki, Director of the Native Department at Tahiti, on the geological structure of this island and of the peninsula of Taïarapoo. The author recognizes the existence of the three regions, distinctly marked out by their botanical features, so well described by Dr. C. Darwin, and undoubtedly essentially connected with the geological history of the island and its gradual rise above the level of the sea. The two crateriform systems of Tahiti and Taïarapoo belong to the first, or eruptive period. During the second period the solidified crust was upheaved to its present level, and torn into radial fissural valleys. The level of the sea during the first period may probably still be traced by means of a corallian girdle running round the whole island below its present summits (3800 ft.). The fossil madrepores mentioned by Mr. Stutchbury (Sir C. Lyell's 'Geology') may probably belong to this girdle, the existence of which, however, may still remain problematic for a long time, on account of the inaccessibility of some part of the island.

Basalt, compact, with olivine, or irregularly columnar,—porose zeolitic lavas,—and trachytes (on the southern portion, and at the east point of Taïarapoo), sometimes decomposed into impure kaolin,

are the prevailing rocks. Conglomerates of volcanic fragments and ashes, with coralline detritus and shell-sand, sometimes more or less distinctly stratified, occur along the coast. The sea-beach is covered either with white coralline or with black volcanic sands, brought there by marine and freshwater currents. At one place there are saturated ferrugineo-carbonic springs. The average atmospheric temperature of Tahiti is 26·1° C.; the normal temperature of springs is 20–21° C. [COUNT M.]

On NEW TRIASSIC CEPHALOPODA *from* HALSTATT. By FRANZ RITTER VON HAUER.

[Proceed. Imp. Acad. Vienna, March, 8, 1860.]

CHEV. FR. DE HAUER, by describing twenty-four new species of Cephalopods from the Halstatt strata, has brought the total of species known to occur in this formation (one of the most abundant in this order at present known) to the number of ninety-two. The majority of these twenty-four new species belong to the genera *Ammonites* and *Nautilus*. A group among them, however, differing from *Ammonites* by their non-dentated lobes and saddles, and from *Goniatites* by their siphonal funnel directed forward, required the establishment of new genera, of great importance as respects the gradual development of the Cephalopods in general, and their relation to other genera of this order. These new genera represent the simplest forms of the Ammonitean family-type, and consequently obtain their full development in the Triassic Period, during which this family makes its first appearance; and they are of but scarce occurrence in the subsequent deposits. [COUNT M.]

On the Phenomena of EROSION *in* NORWAY. By J. C. HÖRBYE.

[Observations sur les Phénomènes d'Érosion en Norvège, recueillies par J. C. Hörbye, Intendant du Musée Minéralogique de l'Université Royale de Christiania, et publiées avec l'autorisation du Sénat Académique par B. M. Keilhau, Professeur de Minéralogie, &c. &c. &c. Avec trois cartes et deux planches. (Programme de l'Université pour le 1er semestre 1857.) 4°. Christiania, 1857.]

THIS work is the result of a large number of observations on the glacial phenomena extending over the whole of the Scandinavian peninsula. These observations are embodied in maps and plates; but are also described in detail in the fifty-six pages of letter-press.

The large map, embracing the southern portion of the peninsula, is coloured, showing at a glance the tabular summits of the mountain-chain, with their deep fiords and gorges ramifying into the heart of the country from the coasts. The directions of the glacial striæ are indicated by arrows at the points of observation. Of the two smaller maps, one shows the direction of the striæ over Norway, Sweden, and Finland; the other (by Th. Rördam) indicates the lines of striation along the Gulf of Christiania.

M. Hörbye's observations lead to the result—that the ice, either as glaciers or floating bergs and floes, had a general tendency to radiate from the central chain. Thus, along the western and

northern coasts, the striæ point westward and northward. Along the Gulf of Christiania there are two systems of striations crossing at a small angle; but, on the whole, pointing southward. Along the eastern and southern slopes the striæ range in the direction of North Germany and Russia, being continued across the plains of Finland; confirming (if any confirmation were necessary) the general belief of the Scandinavian origin of the erratic blocks which are scattered over those countries.

M. Hörbye gives many interesting local details on the subject of *striæ* and *Roches moutonnées*, and the means for determining the direction in which the ice has moved at given points. [E. H.]

On some Greenstones *and their* Secondary Minerals. By Dr. Tschermak.

[Proceed. Imp. Acad. Vienna, March 8, 1860.]

The Greenstones of Neutitischein (Moravia), varied as they are, may be brought under three distinct classes: diorites, simple diabases, and calcareous diabases. The diabases give origin to only a small number of secondary minerals; the diorites are more productive in this respect. The most interesting among them is the serpentine, the origin of which may be traced through the whole series of gradual decompositions undergone by the diorite. The presence of lime in the diorites has had but little influence on the nature of the secondary minerals produced by their decomposition. [Count M.]

On the Lignite *of* Schönstein, Styria. By Dr. Rolle.

[Proceed. Imp. Acad. Vienna, February 3, 1860.]

The geological and palæontological characters of this small lignitiferous basin are those of a secluded lacustrine deposit. The chief materials which have undergone the process of lignitization are, according to Prof. Unger's determination, stem-fragments of *Peuce acerosa*, frequent also in other lignitiferous beds of Styria. Two others of the fossil species from Schönstein agree with some from the Swiss Molasse; whilst two others are undescribed, and not as yet met with in any other locality.

The molluscan remains seem to indicate a less remote geological age than may be inferred from the consideration of the plant-remains alone. Undescribed species of *Bithinia*, *Hydrobia*, and *Valvata*, not known to occur in any other locality, are the prevailing forms. Some few individuals of other species, still living and partly known in the post-tertiary period, may be obtained by washing the fossiliferous marls. None of the Schönstein species are found among the now well-explored molluscan fauna of the Vienna Basin.

From all this Dr. Rolle infers that the lignitiferous beds of Schönstein correspond to a certain group of strata, palæontologically ascertainable only at very few localities, which have been considered either uppermost tertiary or lowermost diluvial, and the most ancient known type of which is represented by the ossiferous strata of the Arno Valley in Tuscany. [Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On the Distribution *of the* Inzersdorf *or* Congerian Strata *in the* Austrian Empire. By Fr. Ritter von Hauer.

[Imp. Geol. Instit. Vienna, Jahrbuch, xi. (1860) p. 1, &c.]

Highly interesting results have been obtained by the recent investigation of the freshwater deposits of South-eastern Europe, undertaken by British officers, especially by Captain Spratt, chiefly during the Crimean war. Captain Spratt had previously given notices of the freshwater deposits near Smyrna, and in the Isles of Samos and Eubœa*, followed by his papers "on the geology of Varna and the neighbouring parts of Bulgaria," "on the freshwater deposits of Eubœa, the coast of Greece, and Saloniki," "on the geology of the North-east part of the Dobrutcha," and "on the freshwater deposits of the Levant†."

In 1858 also Mr. W. H. Baily described a series of organic remains brought from the Crimea by Captain C. F. Cockburn, R.A., with a note by the latter "on the geology of the neighbourhood of Sevastopol," &c.‡

The facts stated in these memoirs, and derived either by the observations of the authors themselves, or on trustworthy authority, are unanimous in proving the existence of freshwater deposits, of the late Tertiary period, throughout S.E. Europe, on the islands and the coasts of the Grecian Archipelago, along the coasts of Thrace and Macedonia, on the Western coasts of the Black Sea, and in the Crimea, and likewise on the opposite coast of Asia Minor. These deposits are considered by Capt. Spratt to indicate the existence of an enormous freshwater lake, or of a series of freshwater basins, during a period immediately preceding the present state of things, so that at that time inland fresh waters filled up the hollows at present for the most part occupied by the salt water of the Ægean, the Sea of Marmora, and the Black Sea.

Capt. Spratt had enounced these views (although somewhat modified by the then existing incertitude as to the age of these isolated

* Quart. Journ. Geol. Soc. vol. i. p. 156, and vol. iii. p. 65 & p. 67.

† Ibid. vol. xiii. p. 72 & p. 177, and vol. xiv. p. 203 & p. 212.

‡ Ibid. vol. xiv. p. 133 & p. 161. This memoir has been followed by another paper by Mr. Baily, descriptive of Crimean Fossils, in the Journ. Roy. Dublin Soc. for January and April 1859, p. 233, &c., with 3 plates.

Tertiaries) some years ago; but Vicomte d'Archiac* doubted the deposits in question to be really of Eocene age, as the late Prof. E. Forbes had believed them to be on account of some of their organic remains. Capt. Spratt himself subsequently regarded the freshwater deposits described by him to be probably of Miocene date; nevertheless his own investigations and those of other geologists indicate them to possess an extraordinary range of diffusion.

In a paper† "On the Freshwater deposits of Bessarabia, Moldavia, Wallachia, and Bulgaria," by Capt. Spratt, read before the Geological Society of London on January 4th, 1860, the author mentions the existence of freshwater deposits on the banks of the Yalpuk Lake in South Bessarabia, containing organic remains similar to those from other localities of the sediments of the great Middle Tertiary freshwater lake. Among them are freshwater species of *Cardium*, occurring also (together with *Dreissena polymorpha*) in the freshwater strata of the Dardanelles and elsewhere. After some search, Capt. Spratt found similar forms living in the Yalpuk Lake, and was thereby confirmed in his conviction of the above-mentioned tertiary basin having really been occupied by fresh water. He supposes a bar (the Isaktcha hills, now broken through by the Danube) to have separated the level of the Black Sea from that of the lake then existing in Bessarabia and the Danubian provinces. The conditions of the enormous freshwater plains in Eastern Europe and in Asia Minor may have been disturbed, he thinks, by volcanic eruptions establishing a communication between the Black Sea and the Mediterranean, altering the level of these regions, and probably in connexion with the formation of enormous gravel deposits along the foot of the Carpathian chain.

It has appeared desirable that the Geologists of the Vienna Imp. Institute should collect the facts recently obtained with respect to the occurrence of freshwater strata in Hungary and Transylvania, and bring them in connexion with those observed by Capt. Spratt. This subject becomes still more interesting when considered in relation with the Caspian Sea and the Aral Lake. These two enormous lakes, with water very poor in salt, may indeed afford some idea of the freshwater basins of S.E. Europe, as supposed by Capt. Spratt to have existed during the Middle Tertiary period. According to the statements of MM. Walmer, Göbel, Rose, Abich, and others, in the water in the north portion of the Caspian Sea, where the rivers Ural and Volga fall into it, there is not above 0·16 to 0·6 *per cent.*, and in the other portions not above 1·2 to 1·4 *per cent.* of salt; while Pisani has found a per-centage of 1·6 to 1·7 in the water of the Bosphorus near Bujukdere; and Erman has recently stated the per-centage of salt in the Mediterranean to be 3·72 in the harbour of Marseilles, 3·79 between Port Vendre and Barcelona, 3·81 between Barcelona and Valencia,

* Hist. Progrès Géol. ii. p. 907.

† For the printed abstract of this and the other papers read before the Geological Society, the author and his colleagues are indebted to the Officers of the Society, who forward them promptly and regularly to Count Marschall.

3·83 near Carthagena, and 3·77 near Malaga,—these numbers representing an average proportion of 3·78.

The Molluscan fauna of the Caspian Sea is remarkable for its extreme scarcity of genera and species, and for the predominance of peculiar forms of *Cardium* (the types of the subgenera *Adacna*, *Monodacna*, and *Didacna* in Prof. Eichwald's 'Fauna Caspio-Caucasica'), as also by its characteristic forms of *Dreissena* and *Mytilus*. Pallas long ago pointed out the far greater extent of the Caspian in ancient times, and its former connexion with the Aral and the Black Sea; and his views have been fully corroborated by subsequent observers, especially by Sir R. I. Murchison, Count von Keyserling, and M. de Verneuil, in 'Russia and the Ural Mountains.'

If we take into consideration the Tertiaries of the plains of the Danube and its affluents, as far as they fall within the limits of the Austrian Empire, beginning with the most thoroughly known among them (namely, those of the Vienna basin), an impartial observer will scarcely have any doubt as to the analogy of the fauna preserved in our Inzersdorf or Congerian plastic clay ("Tegel") with the recent Aralo-Caspian fauna. The deposits just mentioned are very poor in species, but contain very numerous individuals of *Congeriæ* (*Dreissenæ*), together with plenty of *Cardia* (some of them scarcely distinct from Prof. Eichwald's species) and *Paludinæ*, of which one has been identified by M. Frauenfeld* with the recent *Paludina pusilla*, Eichw. Nevertheless the fauna of the Inzersdorf strata is distinct from that of the Aralo-Caspian beds by the presence of *Melanopsis* and other species, connecting them with the other Miocene deposits of Europe.

Prof. Edw. Suess was the first who succeeded in fixing the true position of these Inzersdorf Clays, in relation to the rest of the deposits filling up the Vienna basin. This distinguished palæontologist has proved them to be of newer date than the whole of the marine strata, and to have been deposited above them, in the lowest localities of the basin, at a period when the level of the ancient Miocene sea had already notably decreased, and the per-centage of salt in its water had nearly fallen down to zero by the influx of fresh water. This observation is quite concordant with the fact signalized by the celebrated authors of the above-mentioned work on Russia,—of the Aralo-Caspian freshwater deposits resting on marine Miocene beds; while Capt. Spratt expressly asserts that his freshwater strata rest immediately on Eocene deposits.

The extensive range of the Inzersdorf Clays within the Vienna basin, their occurrence in its lowest portions, the appearance of their organic remains at very many isolated localities (as proved by local occurrences of the characteristic *Melanopsis Martiniana*, enumerated in Dr. Hörnes's 'Tertiary Mollusca of the Vienna basin'), leave no doubt of their having been deposited within this basin in an extensive and continuous lake, the diameter of which from S.S.E. to N.N.W. (from Oedenburg in Western Hungary, to Gaya in Moravia) has a length of 20 Austrian (about 90 English) miles. The

* Hörnes, Die fossilen Mollusken des Tertiärbecken von Wien, i. p. 587.

extent of this lake may have been still greater from east to west, as indicated by the occurrence of Inzersdorf fossils in the Hungarian basin, of which (as the late P. Partsch first proved) the Vienna basin was only a bay. Most probably the waters of both basins were still connected while the deposition of the Inzersdorf strata was going on; at least, these are well developed and very fossiliferous at certain places within the strait between the Leitha and the Rosalia mountain-regions,—that is, in the triangular space between Neustadt, Eisenstadt, and Oedenburg.

Turning from Oedenburg southward to the plain along the margin of the mountain-range, the strata in question are again met with near Schlaning and Rothen-Thurm, S.W. of Güns (W. Hungary), where M. Romer* has noted the occurrence of *Congeriæ*. They disappear, however, within the Styrian bay; at least MM. Andrae and Rolle, who have lately most carefully investigated these regions as the Geologists of the Styrian Geologico-mining Society, could nowhere find the organic remains peculiar to the Congerian beds.

M. Andrae, describing the portion of this bay west of the parallel of Gratz †, mentions the occurrence of sandstones, shales, and clays, partially charged with seams of brown-coal and impressions of leaves (and, on this account, probably of freshwater origin), but containing no fossils characteristic of our Congerian strata. He mentions likewise, as occurring about Grafendorf, Gleisdorf, and E. of Hartberg, limestones with a Cerithian fauna, analogous to the fauna of the strata immediately beneath the Inzersdorf Clays within the Vienna basin; but he gives no indication of any connexion between these limestones (erroneously called by him "Leitha-limestones") and the strata with brown-coal.

The small freshwater basin of Rein, N.W. of Gratz, has been investigated by Prof. Unger ‡ and M. Morlot §, and lately by MM. Peters and Gobanz ||. Of 20 Gasteropods (chiefly of the genera *Helix*, *Planorbis*, *Limnæus*, &c.) determined by M. Gobanz, 16 likewise occur in the freshwater deposits of N.W. Bohemia and in the freshwater limestones of Wirtemberg. None of the characteristic species of our "Inzersdorf Tegel" are among them; only the *Planorbis pseudo-ammonicus*, Voltz, far spread through all freshwater limestones, is common to both these deposits, although of extremely rare occurrence in the "Inzersdorf Tegel."

South of Gratz, Dr. Rolle ¶ has found a not quite continuous bar of ancient rocks (the Plawutsch and Sausal ranges) dividing the Tertiary bay of Gratz into two sections, having very different *facies*. The lignitiferous deposits of the Köflach and Voitsberg bay, and the freshwater deposits with glance-coal of Eibiswald, Steiereg, Wies,

* Verhandl. Vereins Naturk. Presburg, iii. 2nd abstract of Meetings, p. 10.
† Jahrbuch K. K. geolog. Reichsanstalt, v. p. 529.
‡ "Gratz, ein naturhistorisches, &c. Gemälde diesers Stadt," p. 79.
§ "Erläuterungen zur 8. Section d. General-Quartiermeisterstabs-Specialkarte v. Steiermark u. Illyrien," p. 35.
|| Sitzungsbericht. Akad. Wissensch. xiii. p. 180.
¶ Jahrbuch geol. Reichsanst. vii. p. 535.

&c., on the western side of this barrier, are paralleled by Dr. Rolle with the basin of Rein; and so also may be the lignitiferous freshwater strata of Liescha, near Privali (Carinthia), containing, according to M. Lipold*, the same Gasteropodous species. *Congeriæ*, *Melanopsides*, and other characteristic Inzersdorf forms have not been found to occur in any of the localities just mentioned; and the relations of these deposits with respect to the Cerithian strata, conspicuously developed on the eastern side of the above-mentioned bar, on the left banks of the Mur, are still to be ascertained.

If the deposits just mentioned have nothing of the palæontological type of the Congerian strata, it must appear the more surprising to meet this type in the secluded and far more elevated lignitiferous basin of Fohnsdorf, the first exact description of which is due to M. Kudernatsch†. This geologist noticed the presence of *Congeria* and *Paludina* among the innumerable shells filling a bed immediately overlying the lignite; and Dr. Hörnes recognized one of the species to be *Congeria triangularis*.

The eastern portion of the Styrian tertiary region (Fürstenfeld, Feldbach, Gleichenberg, Klöch, and the area comprised between Radkersburg, Pettau, Marburg, and Mureck), as far as it has been surveyed by Dr. Andrae‡, is chiefly occupied by Cerithian strata, to the exclusion of freshwater deposits of less ancient origin. Recent observations from the immediately neighbouring portion of S.W. Hungary have not come to my notice. On the banks of the Balaton lake, near Tihany, our fauna appears again in full development. It was the organic remains of this place (known under the vulgar name of "Goats' hoofs") that first induced the late M. Partsch to undertake a scientific review of the genus *Congeria*. Prof. Zepharovich §, who gave a detailed description of the peninsula of Tihany, found there *Congeria triangularis* associated with *Cardium plicatum*, Eichw., *Melanopsis Dafouri*, Fér., and *Paludina Sadleriana*, Partsch; and above them a bed with *Melanopsis Bouei*, *M. pygmæa*, Partsch (*M. buccinoidea*, Auct.), *Planorbis*, &c.

Further southward the presence of the Inzersdorf strata is at least indicated by the presence of *Melanopsis Martiniana* in the Draun Valley (according to M. Sinnetinger ||), and by the *Congeriæ* and *Melanopsides* (although rather incongruously associated with genuine marine forms) enumerated in M. de Vukotinovic's "Catalogue of the organic remains from the mountains near Agram in Croatia¶." He also describes a limestone with *Melania* and other freshwater shells as occurring in the Mostavina Mountains** (Croatia), leaving it in doubt, however, whether this is of merely local occurrence, or really belonging to the great freshwater lake of the Congerian Period.

In the south portion of the Hungarian basin, the environs of

* Jahrbuch geol. Reichsanst. vii. p. 176. † Haidinger's Berichte, i. p. 83.
‡ Jahrb. geol. Reichs. vi. p. 265. § Sitzungsb. Akad. Wissensch. xix. p. 339.
|| Achter Bericht des geognost.-montan. Vereines für Steiermark, p. 18.
¶ Sitzungsber. Akad. Wiss. xxxviii. p. 343.
** Jahrb. geol. Reichsanst. iii. p. 92.

Fünfkirchen deserve special notice. From Arpad, south of this place, and from Hidas, on the N.E., Prof. M. Majer has sent to the Imp. Museum of Vienna very remarkable *Congeriæ*, of rhomboidal shape (*Congeria rhomboidea*, Hörnes), and large *Cardia*, with wide gaping shells. The geological survey of this district may probably lead to the discovery of the Congerian strata at other localities, especially as M. Vicquesnel* has noticed the occurrence of *Congeriæ*, together with *Planorbes* and *Paludinæ*, in the region of the upper sources of the River Morava in the basin of Pristina at the northern foot of the Schardagh (Turkish Servia). This basin, however, was as little connected immediately with the Congerian sea of Hungary as were those of Fohnsdorf and of Thurocz (the latter to be mentioned presently); but the range of its fauna (isolated in higher horizons) nevertheless extended over these lakes.

Another occurrence of the Inzersdorf fauna on the eastern margin of the Hungarian basin is authenticated beyond doubt. *Dreissena Brandii*, found by M. Kudernatsch† near Kakowa, E. of Werschetz, on the banks of the Karatsch, belongs probably to it. I myself‡ found near Tataros, E. of Grosswardein, numerous individuals of *Melanopsis Martiniana*, *M. Bouei*, and *Cardium* sp. Long previously Dr. Boué§ had observed fossil *Paludinæ* and other freshwater forms near Tirod, on the road from Grosswardein to Klausenburg, and had noticed farther eastward, near Korviczel, at the western foot of the Király-Hago, the presence of marls with *Paludina*, *Planorbis*, *Cyclas*, *Cyrena*, &c., resting on marine strata containing *Pectunculus* and *Natica*.

The most important discovery respecting the subject in question has been brought to light by three borings (still in progress) on the Hungarian plain in the environs of Arad, of which M. Fr. Rath, superintending these operations, has addressed an account to Director Haidinger‖. The easternmost boring, situated within the advanced hills, 3000 feet west of the village of Zabales (in the Circle of Lugos), has been sunk through the following strata:—1. Humus, 6 feet; 2. Yellow and micaceous clay, 9 ft.; 3. Soft, fine-grained, micaceous sandstone, $2\frac{1}{2}$ ft.; 4. The same, somewhat solid, 1 ft.; 5. Sandstone, as under 3, 2 ft.; 6. Sandstone, as under 4, 1 ft.; 7. Soft, yellowish, micaceous sandstone, $30\frac{1}{2}$ ft.; 8. A similar sandstone, with *Cardium* sp. and *Melanopsis pygmæa*, Partsch, 12 ft.; 9. Blue clay, with *Unio*, *Cardium*, *Congeria triangularis*, *Melanopsis Martiniana*, *M. pygmæa*, 32 ft.; 10. Greyish-blue clay, without discernible organic remains, 32 ft.; 11. Yellow argillaceous sand, 63 ft.; 12. Yellowish-grey loose sand, 12 ft.; 13. Bluish-grey, argillaceous, very fine sand (somewhat compact), 18 ft.; 14. Very fine, yellowish, loose sand, 9 ft.; 15. Sandy clay, not yet sunk through, 53 ft.—Total . . 283 ft.

As far as may be judged from the specimens sent, the two other borings, lying farther westward, and wholly in the plain, have not

* Mém. Soc. Géol. France, v. p. 35.
† Haidinger's Berichte, iv. p. 463.
‡ Jahrb. geolog. Reichs. iii. p. 24.
§ Mém. Soc. Géol. France, i. p. 303.
‖ Jahrb. geolog. Reichs. x., Verhandlungen, p. 109.

yet made their way through the Diluvium; at all events they have not yet come down to the Congerian strata. To complete the account, and for comparison, I will give here the list of the strata hitherto worked through by them:—

Allos, S.E. of Arad; the boring 12,000 ft. south of the place:—1. Humus, 5 ft.; 2. Clay, 7 ft.; 3. Clay, yellow and sandy, 24 ft.; 4. Clay, yellow and sandy, 63 ft.; 5. Sand, rather coarse, somewhat coherent, 52 ft.; 6. Clay, 80 ft.; 7. Sand, fine, somewhat coherent, 107 ft.; 8. Clay, 10 ft.; 9. Sandy clay, 12 ft.; 10. Sandy clay, 13 ft.; 11. Fine clay, 73 ft.; 12. Sand, 63 ft.—Total . . 447 ft.

W. of Arad; 6000 ft. east of Pecsa:—1. Humus, $1\frac{1}{2}$ ft.; 2. Fragments and sand (with remains of pottery), $1\frac{1}{2}$ ft.; 3. Loose sand, with rolled pebbles, 72 ft.; 4. Clay, 63 ft.; 5. Like 3, 12 ft.; 6. Clay, with isolated rolled pebbles, 69 ft.—Total . . 219 ft.

The geological maps of older date have no indication of Miocene deposits on the northern termination of the Hungarian plain, at the foot of the Vihorlef and of the Epesies-Tokay mountain-group. When, in the last year, Baron Richthofen and myself surveyed this region, we found thick and extensive Miocene strata surrounding the foot of the mountains; but among them no Inzersdorf strata occurred. The marine strata found by us * either contain *Ostreæ* (as near Tinta), or the characteristic Cerithian forms (Zsujta). The freshwater deposits of small isolated basins have vegetable remains; but *Congeriæ* and *Melanopsides* were not found at any of these localities.

Dr. Hochstetter† found the "Tegel" of Edelény, alternating with lignitic beds (farther westward near Miskolcz), to contain *Helices* and vegetable remains, and to rest on solid grey "Tegel" with Cerithian fossils. The same able observer found at Haugacz (E. of Edelény) strata with *Paludina concinna*, Sow., and *P. Sadleri*, Partsch. M. Jurenak has sent to the Imperial Geological Institute specimens of *Congeria triangularis*, found at Melyarsk near Arenyos, and at Nagy-Erenye near Diósgyör, in searching for brown-coal.

MM. Wolf and Stur's explorations have shown that the marine Tertiaries reach far down south-westward in the Western Comitates (Neograd, Honth, Bars, Neutra, and Pressburg). Congerian strata reoccur only near the Danube, towards the present line of lowest level in the Hungarian basin. We must not, however, neglect to mention, that *Congeriæ*, *Paludinæ*, and *Melaniæ* have been found by MM. Foetterle and Stur in the isolated freshwater basins of Aroa and Thurocz (N. Hungary).

Congerian strata occur more frequently in the middle than at the margin of the Hungarian basin. In the best-known instances they lie between the Lake Neusiedel and Pesth. They continue from Eisenstadt and Oedenburg, on the west bank of this lake, through the localities noticed by MM. Romer‡ and Wolf near Eszterház, at the south-eastern end of the Lake Börczháza (W. of Raab), Szend

* Jahrb. geol. Reichsanst. x. p. 434, &c. † Ibid. vii. p. 699.

‡ Verhandl. Verein. Naturk. Pressburg, iii., 2. Versammlungs-Bericht, p. 16.

and Gics (S.E. of Raab), to Kamorn; and they are known to exist on the north-west of Buda, near Totis, Kömlöd, Al-Czuth, and Tinnye.

The localities on the left bank of the Danube are Tóth-Györk (E. of Waitzou), where Prof. Szabó* found a Congerian stratum resting immediately on Cerithian limestone, and the places where this geologist has marked the occurrence of Congerian "Tegel" on his Geological Map of Pesth, Bude, and the environs†. Such places are—E. of Csepel, on both sides of the left arm of the Danube, here and there near Sfarvas (S.E. of Pesth), in the brick-fields, and near Czinkota (E. of Pesth).

Central Transylvania is known to be completely occupied with Tertiaries immediately connected along the Szamos with those of the Hungarian basin. It has not yet, however, been ascertained whether this connexion existed when the Congerian "Tegel" was deposited. One place, in the main gallery of the Kapnik mines, whence Baron Richthofen‡ obtained specimens of *Congeria triangularis*, through M. Szakmary, is hitherto the only known instance of this genus occurring in North Transylvania.

The Congerian strata are far spread throughout the southern portion of this province; and their frequent occurrence there prove that a great portion of the Transylvanian Tertiaries were deposited in an inland lake. I saw *Congeriæ* and *Cardia* among the specimens from Omlass, near Reismarkt, preserved in the museum of the Transylvanian Society of Natural Sciences at Hermannstadt. *Unio*, *Cardium*, *Planorbis*, *Lymnæus*, &c. are mentioned in M. Ackner's§ Catalogue of the Haunnersdorf fossils. *Congeriæ*, *Melanopsides*, and *Paludinæ*, resembling those of Arapatak, were found between Hettau and Michelsberg, S. of Hermannstadt. M. Ackner also collected *Congeria spathulata*, *Melanopsis Martiniana*, *M. Dufouri* (*M. impressa*, Kraus, and *M. Aquensis*, Grat.), *M. Bouei*, and several *Paludinæ* near Girstau, Szakadat, and Thalheim, places known for their rich Miocene flora. I myself obtained, through M. Nagy-Klausenthal||, a specimen of *Congeria triangularis* from Galt (S.E. of Reps), and some *Cardia* (probably from the same fauna) from Bodendorf (N.W. of Reps). The isolated basin of the "Barzeuland" includes a long-known locality from which M. Nagy-Klausenthal¶ procured for me *Congeria triangularis*, together with several probably coeval forms of *Cardium* from Bodendorf, N.W. of Reps. This basin includes the well-known locality of Arapatak, N. of Kronstadt, where, in the summer of 1859, I collected *Congeria triangularis*, *Cardium*, and a great number of *Paludinæ*, stated by M. Frauenfeld to be *Paludina Sadleriana*, Partsch, *P. semicarinata*, Brard, and *P. Deshayesiana*, Math.

* Jahrb. geol. Reichsanst. x. Verhandl. p. 190.

† Amtl. Bericht der 2. Versammlung deutsch. Naturforscher u. Aerzte in Wien, p. 122.

‡ Jahrb. geol. Reichsanst. x. p. 457.

§ Verhandl. Kais. Leop.-Carol. Akad. xxiv. 2. p. 914; and Verhandl. Siebenbürg. Vereines für Naturwissensch. iii. p. 6.

|| Jahrb. geol. Reichsanst. x. Verhandl. p. 190.

¶ Ibid. x. Verhandl. p. 190.

M. Kerbich* discovered in a northern lateral bay of this basin, near Baroth, Vargyas, and Bazon, a bed of trachytic tuff, including *Congeriæ*, *Neritinæ*, *Paludinæ*, and *Planorbes*, with plenty of vegetable remains.

The facts here quoted agree in proving the diffusion of a fauna similar to the Aralo-Caspian through a series of strata, of a less ancient date than the marine Miocenes in the Vienna basin, over a great portion of this basin, and the whole Danubian depression of Hungary, stretching northward into the Carpathian valleys, and southward as far as the northern foot of the Balkan. The absence of these deposits in the neighbouring regions is a fact no less striking. The strata in question in the Danubian valley do not ascend farther than Vienna; they are not known to exist in the upper Tertiary basin of Austria, nor around St. Pälten; nor in the plain of Tulln: they seem even, according to the facts at present known, to be wanting within that portion of the Vienna basin which is N.W. of a line running along the Bisamberg, the mountains of Nikolsburg, and the Marsgebirg†. The Galician plain, north of the Carpathians, the south-western slope of the Carnian, Julian, and Dinarian Alps, and the plain of the Po have not hitherto afforded the least trace of them. Consequently the western limit of this fauna may be considered as recognizable with a certain degree of certitude.

The localities in Bessarabia and in the Dobrudscha, mentioned by Capt. Spratt, are indicative of an eastward connexion with the Caspian Sea through the Crimea. The question—whether the more southerly freshwater regions on the banks of the Sea of Marmora and around the Ægean Sea, described by Capt. Spratt, were immediately connected with those here described, or whether, on this side, the mountain-chain of the Balkan and that of the Southern Crimea (the continuity of which Capt. Spratt has ascertained by soundings in the Black Sea‡) have acted as a separating barrier,—must remain undecided until the organic remains collected by Capt. Spratt have undergone a stricter determination and an exact comparison with those of the eastern Steppe-limestone and of our northern "Inzersdorf Tegel."

Prof. Suess's investigations have been important in confirming the hitherto somewhat hypothetically asserted difference of age in the Vienna tertiaries, and in proving the deposition of the most recent among them (the Congerian or Inzersdorf Tegel) to have taken place in a freshwater lake. The facts here collected may show (in my opinion) that similar waters filled up the whole Danubian depression subsequently to the marine Miocene period, communicating with coexistent lakes in the Dobrudscha, the Crimea, the borders of the Caspian Sea and of the Aral Lake, and in Asia, as far as the

* Baron Hingenau's "Oesterreichische Zeitschrift für Berg- u. Huttenwesen." 1859, p. 155.

† Suess, "Ueber die Wohnsitze der Brachiopoden," in the Sitzungsber. Akad. Wissensch. xxx. p. 161.

‡ Quart. Journ. Geol. Soc. xiii. p. 80.

Aralo-Caspian strata extend, so as to make possible the migration of certain species from one of these regions to another, since throughout this enormously extensive area the conditions of Molluscan existence (similar to those at present obtaining in the Caspian Sea and the Aral Lake) offered but insignificant differences.

The salt water of the Mediterranean, connected with all the just mentioned depressions when the more ancient Miocene strata were deposited, was perfectly secluded from them during the Congerian period. Subsequently it again advanced to the Gulf of Odessa and the Afourian Sea, when it once more found its way along the depressions made by the sinkings of the Balkano-Caucasian chain. Many deposits containing marine forms of the present age prove the continent to have been depressed beneath its present level during the Diluvial or older Alluvial periods. Future investigations may assist in stating, whether this depression was sufficient to give access to sea-water as far inland as the Hungarian plain (the loose sands of which are considered by Baron Richthofen* to be of marine origin) and the Vienna basin, in the erratic diluvium of which remains of marine shells have been discovered by Prof. Suess†.

[Count M.]

Some Sections of the Congerian *and* Cerithian Strata *in* Hungary *and* Austria. By MM. Stur and H. Wolf.

[Proceed. Imp. Geol. Instit. Vienna, April 17 & April 24, 1860.]

1. *Between Modern and Bösing (Western Hungary, near the frontier of Austria).* [Stur.]—These strata, arenaceous, with minute particles of mica, are particularly developed at the church-yard of Terlink and near the village of Zukersdorf. Dr. Kornhuber found in them *Cardium Vindobonense*, Lam., *Donax Brocchii*, Defr., *Turritella bicarinata*, Eichw., *Lucina Columbella*, Lam., *L. divaricata*, Lam., *Arca Diluvii*, Lam., and *Ostrea lamellosa*, Brocc.; this last perforated by parasitic shells. A section of these strata, taken on the steep banks of a rivulet, shows in descending order:—1. Loam or Loess; 2. Sand; 3. Sandstone (3–4 inches); 4. Sand, abounding with Molluscan remains (2–3 feet); 5. Calcareous, soft, porous sandstone, with Molluscan fragments like those of No. 4 (1 ft.); 6. Greenish "tegel," or clay, imperfectly laid bare, with fragments like those of No. 5.

Another section, 48–60 feet N.W. from the first one, and 3–4 feet above it, showed in descending order:—1. Loess; 2. Coarse felspathic sands, alternating with greenish clay (both assuming brown tints in contact with the air); 3. Clay (scarcely 2 inches), with *Congeria subglobosa*, Partsch, and *Melanopsis Martiniana*, Fér.; 4. Sand (4–5 inches); 5. Coarse soft sandstone, like No. 5 of the first section, but certainly higher in relative position; 6. Sands, like No. 4 of the first section, with the same Mollusca. Nos. 4, 5, and 6 yielded

* Jahrb. geol. Reichsanst. x. p. 459. † Ibid. x. Verhandl. p. 100.

Mactra Podolica, Eichw., *Donax lucida*, Eichw., *Cardium Vindobonense*, Lam., and a single badly-preserved specimen of *Cerithium pictum*, Bast.

It may be inferred from these sections, that in the locality in question the yellow sands, sandstones, and calcareous porose sandstones, corresponding to the Cerithian strata of the Vienna basin, are overlaid by strata of greenish clay and felspathic sandstones with *Congeriæ*. The occurrences here described seem to be strictly local. In the vicinity the yellow (probably Cerithian) sands are immediately overlaid by diluvial detritus, so that the presence of *Congeriæ* may be supposed to indicate the former existence of a local freshwater current.

2. *Near Sereth* (*Buktowina*). [Stur.]—A hill of grey sandstone, in nearly horizontal layers, with intercalated marls, opened by quarries, gave the following organic remains (more frequent in the marls than in the sandstone itself):—*Murex sublavatus*, Bast. (?), *Cerithium mitrale*, Eichw. var., *Rissoa inflata*, Andrz., *R. angulata*, Eichw., *Bulla*, sp. (*B. Pupa*, Eichw.?), *Vermetus intortus*, Lam., and *Ervillia Podolica*, Eichw., which, although but indifferently preserved, indicate a fauna corresponding to that of the Cerithian strata in the Vienna basin.

3. *Between Netzendorf and Speising* (*about three English miles W.S.W. of Vienna*). [H. Wolf.]—The Wiener Berg, running south of Vienna in an E.-W. direction, shows exclusively Congerian strata in its central portion near Inzersdorf. In its westerly continuation (hills of Meidling and in or near Schönbrunn) Cerithian strata, dipping, at low angles and with various undulations, eastward beneath the Congerian strata, make their appearance. A railroad-section has laid bare Congerian strata, only a few feet thick, while about 4200 feet eastward their thickness exceeds 70 feet. These strata, dipping slightly eastward, with various undulations, are, in *descending* order, as follows:—

1. Rolled fragments of Vienna Sandstone (1–2 feet); 2. Undulated seam of yellow sands (3 inches); 3. Blue plastic "tegel" (2 feet); 4. Undulated yellow clay (4 inches); 5. Bluish-grey sandy "tegel," with *Cardium conjungens* in its upper part, and with *Congeria Partschi*, Cz., and large nodules of calcareous marls including plant-remains, in its lower portion (5–6 feet); 6. Sand of minutely triturated Shells, with an intercalated band of small fragments of Vienna Sandstone (16 inches); 7. Sandstone, with *Congeria spathulata*, Partsch; 8. Grey sands (1 foot); 9. Yellow sands, with triturated Shells (6 inches); 10. Grey sands (4 feet); 11. Gravel of Vienna Sandstone, not yet sunk through. At two other places this gravel is exposed to the thickness of above 6 feet, overlaid by nearly 1 foot of sands, in an undulated layer, dipping eastward.

North of the west end of Hetzendorf, the railroad has cut through 1 foot of soil, 1 inch of sandstone, and 18 feet of "tegel," which has been penetrated by a pit as far as the Cerithian sandstone immediately under it. The portion next to the sandstone was found to contain *Cardium Vindobonense*, Partsch, *Mytilus carinatus*, Br.,

and *Tapes gregaria*, Partsch, a characteristic form of the Cerithian series. The stratum with *Tapes gregaria* (about 18 feet beneath the surface) is undulated, and crops out at a distance of 480 to 600 feet westward. From this place the section increases in depth, and the following strata are observed to come successively to day in a distance of 1920 feet:—

	feet.	in.
Sands	1	0
Gravel of Vienna Sandstone	0	6
Cerithian sandstone	0	8
Gravel of Vienna Sandstone	0	2
Cerithian sands	0	8
Sandy clay	0	2
Cerithian sandstone	0	6
Cerithian calcareous marl	1	2
Calcareous clay, with white calcareous stripes	0	5
Yellow sands with Cerithian patches	1	4
Gravel of Vienna Sandstone	0	6
Solid "tegel," with calcareous nodules	1	0
Cerithian calcareous marl	0	8
Rolled pebbles of Vienna Sandstone	0	8
Sandy clay with isolated pebbles	3	0
Pebbles of Vienna Sandstone, considerably rolled, with irregularly interspersed concretions of Cerithian sandstone	2	0
Loose Cerithian sands	1	0
Minute gravel of Vienna Sandstone	0	10
Grey sands	0	6
Coarse pebbles	0	4
Cerithian sands	1	3
Greenish "tegel," with calcareous concretions	3	0
Marly calcareous layers	2	0
Rust-coloured sands	0	2
Conglomerates of pebbles of Vienna Sandstone	3	0
[Here the strata crop out at higher angles.]		
Grey sands	5	0
Sandy clay, with rolled pebbles	0	8
Grey sands	2	0
Coarse gravel of Vienna Sandstone	1	6
Tough yellowish-brown clay	2	0
Sands with gravel, passing downwards into sandstone	2	6
Tough calcareous clay, with isolated calcareous stripes	4	0
Conglomerates, with large rolled fragments, some of several cwts.	6	0
Green argillaceous sands, with isolated patches of gravel	1	8
Tough yellow clay	2	6
	55	0

A bluish argillaceous sand terminates the section. About 240 feet from it, a well has been sunk through the "tegel" to a depth of 18 feet, and about 12 feet beneath the yellow clay, concluding the above-mentioned section. The "tegel" is interrupted by a single narrow seam of sand, permeable to water. *Operculina complanata*, some Bivalves (including a *Modiola*), and *Turritella bicarinata* have occurred in this "tegel," which is analogous, as it seems, to that of Poetzleinsdorf, N.W. of Vienna. Wherever this "tegel" has been sunk through to the depth of 30 to 42 feet, powerful springs of water, issuing from the Cerithian sands immediately beneath it, have been obtained. The altitudes above the level of the Adriatic are:—

		feet.
Congerian "tegel" at the end of the junction-railroad near Hetzendorf		666
Cerithian sandstone	at the Gloriette of Schönbrunn	759
	lower limit, at the railroad-section	703
Poetzleinsdorf sands near Speising		678

[COUNT M.]

On the Tertiary Eruptive Rocks *of* Hungary *and* Transylvania. By Baron Richtofen.

[Proceed. Imp. Geol. Instit. Vienna, April 24, 1860.]

The eruptive region extending from Persia, over Asia Minor and Hungary, to the Siebengebirge and the Eifel on the Rhine, is represented on the south slope of the Carpathians by seven distinct groups, either concentrated into masses, or spreading in long ranges. These groups are, 1st, the Schemnitz Mountains; 2ndly, those of Visegrad, broken through by the Danube between Gran and Waitzen; 3rdly, the Matra; 4thly, the Tokay-Epesies group; 5thly, the Hungarian; 6thly, the Transylvanian Vihorlet-Gatin (the second known under the special name of Hargitta); and, 7thly, the metalliferous mountains of Transylvania. The materials of all these mountains, which, from their prevailing constituents, may be comprised under the general designation of trachytic rocks, exhibit, as does the great European-Asiatic range, in its totality, three distinctly limited groups:—1. the *Rhyolitic*; 2. the *Trachytic*; and 3. the *Basaltic* group; the last of them being, as it seems, exclusively represented by Basalts; the occurrence of Phonolites, Dolerites, and other analogous rocks having not yet been duly ascertained.

The second group is by far the most prevalent, being nearly exclusively represented by amphibolous oligoclastic varieties, vitreous felspar (sanidine) being only conspicuous in some subordinate eruptions of more recent date. Silica is never abundant enough to appear in independent secretions. There exists a double parallel series, of greenstone-trachytes, on the one, and of grey trachytes on the other side, both being compounds of amphibole and oligoclase, subordinately including augite, whenever silica is diminishing. The greenstone-trachytes are characterized by an abundance of metalliferous minerals, by their easy decomposition, their peculiar outlines, and their geological age, being constantly of older age than the grey trachytes. The same peculiarities have been observed in the trachytes of Asia Minor and Mexico; their real cause, however, still remains unknown.

The designation of "rhyolitic group" is proposed for the totality of the most eminently siliciferous among the eruptive rocks of comparatively less remote date, being equivalent to the quartziferous and non-quartziferous eruptive porphyries among the older porphyritic rocks. The excess of silica, generally secreted in the shape of quartz-crystals, gradually diminishes, and at last completely disappears. Beyond this limit the rhyolitic group continues through a series of sanidine rocks, with accessory presence of oligoclase. Although chemically and mineralogically the transition of rhyolite into trachyte may become so imperceptible, that, in some cases, hand-specimens may leave some doubt concerning their real nature, both these groups, in the Hungarian mountains, are so distinctly characterized, that any geologist observing them *in situ* cannot be perplexed about them. Beudant applied to certain varieties the designations of "trachytic porphyry," "perlite," and "millstone-porphyry," which Abich comprised under the general category of

"trachytic porphyry." Certain accidental modifications of structure received the denomination of perlite, pumice, obsidian, &c., together with a special place in the system. The geological facts within the Hungarian mountains and our present knowledge of the phenomena of solidification dissipate any doubt concerning the narrow relation between these varieties, as already supposed by Beudant. The general denomination of "trachytic porphyry" would imply something quite different from its real signification and be a source of many errors. Rhyolite, as the denomination of a whole group, would at least draw attention to a common character of all its subdivisions, all bearing traces of igneous fusion, and resembling either glass or China-ware, or real lava-currents.

The series in geological age, beginning with the most ancient group, is—greenstone, trachyte, rhyolites, and basalts. The first two are everywhere in essential mutual connexion. Basalt is independent of both, and appears in isolated groups, rarely encroaching on their dominions. Trachyte has exclusively broken out to day in masses following extensive and precisely determined fissures, and towering into large mountain-ranges. Rhyolite, as it were a parasitical formation, occupies the flanks or the basis of the trachytic groups or ranges, appearing but rarely and very subordinately in massive eruptions. It is essentially a result of genuine volcanic activity, an ancient lava, having flowed out of craters, or through fissures in the walls of volcanos or in the slopes of trachytic ranges. The basalt is equally eruptive and volcanic. The eruption of greenstone-trachyte is a continental one. Subsequently to them the level of the land was lowered, so that the grey trachytes were enveloped at the very moment of their breaking out by layers of tuffs, partly alternating with them.

These trachytic tuffs are of high importance in the tertiary eruptive formations of Hungary. The series of craters lying along the foot of the trachytic mountains, which gave issue to the rhyolitic current, began to be active only after the completion of the trachytic eruption and the subsequent invasion of sea upon the dry land. These eruptions bear over a large area well-defined marks of periodical modifications in the nature and mode of formation of the eruptive rocks, testifying to a gradual emergence of land and retreat of sea during the rhyolitic period. It begins with submarine eruptions, and ends with a series of diminutive eruptions on dry land. Another depression may have taken place previously to the eruption of basalts, these being likewise connected with considerable deposits of tuff.

The three groups of Tertiary eruptive rocks, as proposed here, are not confined to the South Carpathian slopes. We find them again in Central Germany, where the first two of them are almost wanting; in Asia Minor and on the Armenian plateau; in the Euganeans, where the trachytic group, as the most ancient, is followed by the perlites of the rhyolitic group, and this, apart from the rest, by the basalts of the Vicentin; in Iceland, where the basic compounds have taken the place of the rhyolites; in New Zealand (according to Dr. Hoch-

stetter's observations); in Mexico, where Von Humboldt has described the phenomena just as they occur in Hungary; greenstone-trachytes being the oldest rocks, followed by grey trachytes (andesite), and then by rhyolites, with the usual circumstances of siliceous concretions in shape of opals, &c. As with those of Hungary, the Mexican greenstone-trachytes are the chief bearers of auriferous and argentiferous ores.

[COUNT M.]

On a NEW FOSSIL SAURIAN *from* COMÈN, ISTRIA. By HERMANN VON MEYER.

[Proceed. Imp. Geol. Instit. Vienna, January 31, 1860.]

A SLAB of stone from Comèn, in the district of Goritzia, containing some finely preserved remains of a Saurian, and belonging to the City Museum of Trieste, has been examined by H. von Meyer, who pronounces the Saurian of Comèn to be a Lacertian, with concavo-convex vertebræ, connected with Prof. Owen's genera *Dolichosaurus*, *Coniosaurus*, and *Raphiosaurus* of the English Cretaceous deposits. All the Lacertians of earlier periods, even those of the lithographic stone, show no convexity on the posterior articular surface of their vertebræ; so that, not considering the development of the rest of their structure, they would seem to bear an embryonal character.

The Comèn Saurian is but of half the size of the above-named English genera, standing next to *Dolichosaurus longicollis*, to which it is connected by its lengthened, narrow, and cylindrical shape (thus recalling to mind the recent serpentiform genera *Pseudopus*, *Bipes*, and *Ophiosaurus*, with imperfectly developed extremities), and by its probably long neck, consisting (as some circumstances seem to indicate) of a great number of vertebræ. This last character is too important to be confined to a single genus; it may be supposed to have been common to several other Cretaceous Lacertians with concavo-convex vertebral articulations, although not yet made evident by preserved remains.

Prof. Owen infers, from two specimens found in the same locality and at the same time, that his *Dolichosaurus longicollis* possessed 40 vertebræ between the neck and the pelvic region. The uncommonly well-preserved individual of Comèn has only 27 vertebræ—a circumstance warranting the establishment of a new genus, for which H. von Meyer proposes the name of *Acteosaurus* (from ἀκτή, strand, the specimen having been found in the Istrian shore, and its original having probably lived along the sea-coast), with the specific denomination of *Act. Tommasinii*, in honour of the Podestà of Trieste, Cavaliere Tommasini, who gave it to the museum of that city.

The anterior extremities of *Acteosaurus*, although fully developed, are of a remarkably small size; the length of the radius is to that of the humerus as 5 to 7, to the femur as 1 to 2. The proportion of the tibia to the femur is 4 to 7. The carpal and tarsal bones are

completely ossified; the rotula is perfectly recognizable under the form of a small wedge-like bone. Both pairs of extremities are pentadactylous. The number of the anterior phalanges cannot be exactly stated; the number of the posterior phalanges (without the metatarsal bones, but with the imperfectly developed ungular phalanx) is represented by the following series: 2, 3, 4, 5, 3, beginning with the hallux; so that the fifth finger has one phalanx less than those of the recent Lacertians and the analogous forms from the lithographic stone.

The bones of the Comèn specimens are changed into a substance of metalloid aspect, like steel or oxydated manganese; and the matrix is uncommonly heavy: both deserve to be submitted to chemical analysis. The hollow stripes on the surface of the bones seem to be indicative of the commencement of an imperfect crystallization.

[Count M.]

On some New Tertiary Fishes. By M. Steindacher.

[Proceed. Imp. Acad. Vienna, March 22, 1860.]

M. Steindacher has determined seven new species of fishes belonging to the Tertiary period. Five of them (*Gobius Viennensis*, *G. clotus*, *G. oblongus*, *Clypea elongata*, and *Cl. melettæformis*) have been found in the "Tegel" of Hernal (N.W. of Vienna); a sixth (*Phycis Suessi*), of a genus of which hitherto no fossil representative was known, comes from the "Tegel" of Inzersdorf (S. of Vienna); the seventh is a *Syngnathus* from Radoboj (Croatia), remarkable for being the first known fossil representative of a still existing genus of Lophobranchians, all the individuals of this family hitherto found fossilized belonging, without exception, to genera now extinct.

[Count M.]

On some Eruptive Phenomena *seen in the* Dachstein Mountains. By Prof. E. Suess.

[Proceed. Imp. Acad. Vienna, April 12, 1860.]

Eruptive phenomena have been observed by Prof. Suess in the Dachstein mountain-group (Upper Austria), which is composed of a great calcareous "massif," with steep cliffs all around, intersected by a great number of faults. In these faults and on the elevated portions of the "massif" are found agglomerations of rolled fragments, originating from rocks of more ancient date, on which the calcareous mass rests. Many of these fragments have a particularly bright and polished surface; some of them have penetrated into the narrowest clefts of the limestone; others have been broken by violent compression, or have, as it were, forced their way into the surrounding limestone. The rolled fragments of the tops belong exclusively to the "Werfen Slate" or to the Greywacke. Among those in the Koppenbrüller cave, at the foot of the mountain-group, crystalline rocks prevail. These last must have undergone a still more considerable upheaval than those on the top, which may have been upheaved to an elevation of nearly 10,000 feet. [Count M.]

TRANSLATIONS AND NOTICES

OF

GEOLOGICAL MEMOIRS.

On METEORITES. By Director W. HAIDINGER.

[Proceed. Imp. Acad. Vienna, April 19, 1860.]

DIRECTOR HAIDINGER read a paper on the external form of meteoric stones, prepared long ago for publication, and essentially connected with a lecture on the same subject lately delivered by Prof. Kenngott before the 'Scientific Society' of Zurich (Oct. 31, 1859). The paper was illustrated by drawings of two meteoric stones; one from Stannern (May 22, 1808), the other from Gross-Divina (July 24, 1837). The shape of these two specimens and the nature of their crust are such as to lead to inductions concerning the direction they may have followed when rushing through the atmosphere. The bright crust of the Stannern meteorite seems to show all over the effect of an atmospheric current, which has formed along the whole outline of the mass a roll-like pad, prominent backwards. The crust of the Gross-Divina stone is rough on the hinder side, smooth on the front, showing the well-known rounded impressions, which Dir. Haidinger supposes to be the effects of fusion, undergone in a rare medium or in a vacuum, protected from the influence of the atmosphere.

The author distinguished two well-defined and consecutive periods between the formation of a meteorite and the moment at which it touches the terrestrial surface. During the first, or cosmical, period, the igneous globe is formed under the influence of resisting air, its end being marked by an explosion, indicating a sudden intrusion of atmospheric air into the imperfect vacuum existing within the slowly moving igneous globe. During the second, or telluric, period, the meteoric mass simply falls, exactly as any other body would, subject to the law of gravitation.

Meteorites wholly covered with a crust must have reached the circuit of terrestrial atmosphere as isolated individuals: they cannot be supposed to be fragments of a mass whose explosion took place at the moment when the igneous globe disappeared. The meteor of Gross-Divina produced but one single mass; while that of Stannern may be said to have been followed by a rain of meteorites.

Baron Reichenbach, in some papers published in Poggendorff's 'Annalen der Physik,' has defended the opinion that meteorites owe their origin to an aggregation of minute globules or crystals analogous to those which he supposes to exist in the tails of comets. Haidinger and Kenngott, on the contrary, think these problematic masses to be simply compounds of various mineral substances bearing an indubitable analogy with the rocks constituting the solid crust of the terrestrial globe. Baron Reichenbach quotes, in favour of his theory, Mr. Brokedon's experiment with pulverized graphite, which, having been freed by exhaustion from the air that adheres to the surface of any powder, and submitted to moderate compression, was converted to a compact mass like native graphite; but he omitted to say that, the air having been removed, the experimenter made repeated use on his graphite-powder of a compressing apparatus having a force that may be estimated as high as 20,000 cwt. Prof. Schrötter's ingenious experiments have proved that the action of chemical affinity completely ceases under a temperature of 80° C. below zero; so that even substances whose chemical union under normal atmospheric temperature is attended with most violent explosions may be safely brought into mutual contact. The temperature of the interplanetary space through which the igneous globes make their way is probably not above $-100°$ C. (even $-140°$ C. according to M. Pouillet); so that the fact stated by Schrötter is a weighty objection against Baron Reichenbach's theory, at the same time that it confirms the views of Haidinger and Kenngott.

[COUNT M.]

On the RED SANDSTONE *and* CRETACEOUS STRATA *of* CENTRAL BOHEMIA. By M. LIPOLD.

[Proceed. Imp. Geol. Instit. Vienna, January 31, 1860.]

THE Red Sandstone formation in the mountain-region of the Circle of Prague is far less complicated than that of N.-E. Bohemia, consisting only of sandstones and shales, the petrographic characters of which, and especially their red tints, distinguish them from the analogous strata of the Carboniferous formation which they overlie everywhere in conformable stratification. The thickness of the red sandstone is but insignificant in comparison with the Carboniferous rocks. Its average dip is 10–20° N.

The only known organic remains from this sandstone are a few Fish-remains, and from these Prof. Reuss has inferred that the coal-strata of the localities where those remains have been found are subordinate to the red sandstone.

The Cretaceous group is only represented by its lowermost members,—the "Quader-Sandstein" (Lower Quader), overlain by the "Pläner-Sandstein." The thickness of both does not exceed 60 feet. The strata are horizontal, or with a slight northerly dip. Argillaceous strata, ½ to 5 feet thick, with isolated seams of coal, are frequently

intercalated between the Pläner and Quader, and also beneath the second of these deposits.

The whole Cretaceous deposits are fossiliferous, though not richly so. The only vegetable remains known to occur in them is *Araucaria acutifolia*, Corda, in one isolated Pläner locality. The animal forms of the Quader are *Prococardia Hillana*, Sow., *Pinna decussata*, Goldf., and *Turrilites*. Those of the Pläner are *Inoceramus mytiloides*, Mantell, *In. Crispii*, Mant., *Ammonites peramplus*, Sow., *Am. Rothomagensis*, Defr., *Pecten*, and *Cardium*. The Pläner-Mergel on the north-west slope of the basaltic hill of Slana offer quite a different aspect, being characterized by the occurrence of teeth of *Squalidæ*, *Baculites*, *Ammonites* (related to *Am. varians* and *Am. inflatus*, Sow.), *Nucula*, *Arca*, *Pecten*, and *Gasteropoda*.

The highest horizon of the Cretaceous deposits N.W. of Prague is 1669 feet above the sea-level. These deposits may be supposed to have originally occupied a continuous surface: at present they are separated into long-extended ridges and isolated plateaux by valleys of erosion and ravines, cutting through them and exposing to view the underlying red sandstone and Carboniferous strata. [COUNT M.]

On some LIGNITE *of* SCHÖNSTEIN, STYRIA. By Dr. ROLLE.

[Proceed. Imp. Acad. Vienna, February 3, 1860.]

THE geological and palæontological characters of this small lignitiferous basin are those of a secluded lacustrine deposit. The chief materials which have undergone the process of lignitization are, according to Prof. Unger's determination, stem-fragments of *Peuce acerosa*, frequent also in other lignitiferous beds of Styria. Two others of the fossil species from Schönstein agree with those from the Swiss Molasse; whilst two others are undescribed, and not as yet met with in any other locality.

The Molluscan remains seem to indicate a less remote geological age than may be inferred from the consideration of the plant-remains alone. Undescribed species of *Bithynia*, *Hydrobia*, and *Valvata*, not known to occur in any other locality, are the prevailing forms. Some few individuals of other species, still living and partly known in the post-tertiary period, may be obtained by washing the fossiliferous marls. None of the Schönstein species are found among the now well-explored molluscan fauna of the Vienna Basin.

From all this Dr. Rolle infers that the lignitiferous beds of Schönstein correspond to a certain group of strata, palæontologically ascertainable only at very few localities, which have been considered either uppermost tertiary or lowermost diluvial, and the most ancient known type of which is represented by the ossiferous strata of the Arno Valley in Tuscany. [COUNT M.]

On the Coal-plants *of* Bohemia. By M. Stur.

[Proceed. Imp. Geol. Instit. Vienna, March 13, 1860.]

The fossil plants from the Coal-basin of Rakonitz (Bohemia) present 53 species, and may be subdivided into four distinct local floræ. These species are distributed among 21 genera of 10 families.

Calamiteæ (Calamites)	3
Asterophylliteæ (Asterophyllum, Annularia, Sphenophyllum)	6
Neuropterideæ (Neuropteris, Nœggerathia, Schizopteris, Dictyopteris)	6
Sphenopterideæ (Sphenopteris)	5
Pecopterideæ (Asplenites, Pecopteris, Alethopteris, Cyatheites)	13
Stigmarieæ (Stigmaria)	1
Sigillarieæ (Sigillaria)	4
Lepidodendreæ (Lepidodendron, Knorria, Lepidostrobus, Cardiocarpon)	12
Lycopodiaceæ (Cordaites)	2
Palmaceæ (Flabellaria)	1

The following species, *Calamites communis, Annularia fertilis, Nœggerathia foliosa* (particularly frequent around Rakonitz), *Alethopteris pteroides, Cyatheites Miltoni, Stigmaria ficoides, Lepidodendron Haidingeri,* and *L. aculeatum,* as also the *Sigillarieæ,* occur generally in considerable number as individuals.

Calamites communis, Annularia fertilis, Cyatheites oreopterides, C. Miltoni, C. arborescens, Stigmaria ficoides, Cordaites borassifolius, and *Flabellaria Sternbergi* occur both in the shales forming the roof of the coal-bed and in those immediately beneath it, so that the flora of both these shales may be considered as nearly identical; and the existence of *two distinct Floræ* within the basin of Rakonitz may indubitably be admitted: the one of *Asterophylliteæ, Neuropterideæ, Sphenopterideæ,* and other genera of *Filices* and *Lycopodiaceæ,* containing but a small portion of carbonaceous substances; the other, *Sigillariæ* and *Lepidodendra,* which have chiefly contributed materials to the coal-bed. Two species (*Knorria imbricata* and *Lepidodendron* (*Sagenaria*) *Veltheimianum*), found in some few fragments within the Rakonitz basin, are characteristic of the lowest strata of the Carboniferous group.

The flora of this basin bears a striking general resemblance to that of Radnitz (known long ago through Count C. Sternberg's splendid publications), and to the flora of the coal of Zwickau (Saxony), lately described and figured by Prof. Geinitz. Some few species, however, occurring in the basin of Rakonitz, are wanting in the coal-measures of Radnitz; these are *Sphenopteris rutæfolia, Asplenites cristatus, Alethopteris aquilina, Al. pteroides, Al. muricata, Cyatheites Miltoni, Cy. unitus, Cy. dentatus, Sigillaria mammillaris, S. oculata, S. elongata.* [Count M.]

ALPHABETICAL INDEX

TO THE

PROCEEDINGS OF THE GEOLOGICAL SOCIETY.

[The fossils referred to are described, and those of which the names are printed in italics are also figured.]